THE Petroleum Engineer

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VOLUME VI NUMBER III

A MAGAZINE OF METHODS FOR OPERATING MEN

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Meetings

Society of Automotive Engineers, Annual Dinner—January 7, New York City.

Society of Automotive Engineers, Annual Meeting—January 14, 15, 16, 17 and 18, Book Cadillac Hotel, Detroit, Michigan.

American Institute of Mining and Metallurgical Engineers, Petroleum Division, Annual Meeting—February 18, 19, 20 and 21, New York City.

American Association of Petroleum Geologists—March 21, 22 and 23, Wichita, Kansas.

Petroleum Industry Electrical Association—April 11, 12 and 13, Baker Hotel, Dallas, Texas.

American Chemical Society, Semi-Annual Meeting — April 22, New York City.

Pennsylvania Grade Crude Oil Association, Annual Meeting — June 20 and 21, State College, Pennsylvania.

American Society for Testing Materials, Annual Meeting —June 24, 25, 26, 27 and 28, Book Cadillac Hotel, Detroit, Michigan.

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The Course of Oil

By K. C. SCLATER

Engineering Principles in Producing Oil

Stripped of all legal and political obstacles the difficulties of the petroleum industry, so far as the engineer is concerned, are not so involved as one might be led to expect by the mass of conflicting opinion expressed before the Congressional Committee at its recent investigation hearings.

The petroleum production engineer is primarily concerned with the economical production of oil; that is, in obtaining the greatest ultimate recovery of oil at the lowest unit cost. By conducting oilfield operations according to this principle he not only meets the desires of his company but also develops his company's holdings under a system that must eventually inure to the benefit of the consuming public and contribute to the national welfare.

This he can do without encroaching on the rights of other companies or individual operators in a pool. It is to be emphasized that no insuperable technical difficulties are involved. The trouble likely to be encountered lies beyond the province of the engineer for solution. It is the unscrupulous operator who violates good production practice to the serious detriment of the other interests in the pool.

Allocating Allowable Production

When curtailment is necessary, the allocation of allowable production in flush and semi-flush fields on the basis of potential capacity to produce without regard to reservoir conditions and recoverable reserves is fundamentally unsound. The maximum rate at which wells are capable of producing bears no relation to the underground reserves underlying each well. So long as this unsound and arbitrary method of allocating allowable production is followed, many of the evils of destructive, competitive field practice will remain. When any question involving methods of allocating allowable production comes up for discussion, reasoning is prone to be warped by experience gained prior to the introduction of advanced engineering methods. As a result, a reluctance to take a progressive step asserts itself.

Reservoir conditions can be ascertained with a reasonable degree of practical accuracy early in the life of a pool, and are a reliable guide to the development and production practices that should be followed. Recognition of this fact is not enough. What is required is a wider application in actual practice of the principles upon which this fact is founded. The self-enlightenment that would come to the industry by following such a course would more quickly bring about voluntary suppression of vicious production practices, and eradicate many of the evils affecting other branches of the industry.

Production Costs Vary Widely

Production costs frequently is a subject of confused and fallacious reasoning. No matter how efficient and exact the method of producing oil, there is—and probably always will be—a large element of gamble in the search for oil up to the point of its actual discovery. Large expenditures are entailed before oil is discovered, the effect of which on production costs is often overlooked.

Petroleum is a natural raw material that is subject to the vagaries of nature to a greater degree than any other natural raw material. On adjacent properties production costs in the same pool may differ widely because of the large variation among the elements comprising production cost. In the average pool, the production cost is low during the flush stage of production and high during the pumping life. So when we speak of the production cost of a barrel of oil and wish to make intelligent comparisons, every element of cost must be considered. One company may have paid very high prices for its leases in the vicinity of a pool and then have expended large sums in wildcatting and dry holes before production was obtained. Another company in the vicinity of the same pool may have purchased its leases at a small figure and have been fortunate enough to make a highly productive well out of every hole drilled. The production costs of these companies would be affected accordingly. Thus does the element of legitimate gamble affect production costs.

There are other ways in which production costs are affected. An operator may go into a field, develop certain leases, and produce them during the flush and semi-flush period. Before the pumping period is reached he sells out his interest and then seeks flush production elsewhere. Good luck, rather than efficient producing operations, might enable such an operator for a time to produce oil at a low cost and without the application of any engineering principles, but as his producing operations expand the element of risk and likewise production costs, are likely to increase.

Strictly speaking, production costs for comparison should really be based on the average cost over the entire life of a field or pool. Were all pools produced at their optimum rate the difference in production costs between the beginning and closing periods of the pool's life would be less marked. That is to say, a pool produced at its optimum rate will result not only in a lower but in a more uniform lifting cost over the life of the pool than if produced otherwise.

Indicative of the variations in production cost that are actually encountered are the average production costs in three of the major oil fields of the country. For the three-year period, 1931 to 1933 inclusive, Oklahoma City had an average production cost of 85 cents, East Texas 55 cents, and Kettleman Hills 9 cents per barrel of oil produced. For the three-year period, 1931 to 1933 inclusive, California had a bare operating expense of 21 cents, the Mid-Continent 18 cents, and the Rocky Mountain region 34 cents, and Eastern fields 58 cents per barrel of oil produced.

Despite the fact that oil has to be produced from an increasingly greater depth, the average production cost per barrel of oil produced in the United States for the four-year period, 1927 to 1930 inclusive, was $1.05, as against $0.81 for the three-year period, 1931 to 1933 inclusive. These costs are based on fields most of which were developed under highly competitive conditions, and are from a recent report of the Petroleum Administrative Board on the cost of crude production. The evidence of progress and improvement in production practice is obvious from these figures.

It is realized, of course, that the prevailing market price might enter to modify the rate at which oil would be produced from a pool; however, were all pools to be operated at their optimum rate the probabilities are that fluctuations in the price of oil would be less violent. Even were it necessary to curtail production, the flow of flush and semi-flush pools under proper control could be restricted without any serious loss in producing efficiency or increase in production costs.

« « « HIGHLIGHTS IN OILDOM » » »

Texas Tender System Made State-Wide

The Texas Railroad Commission has issued orders instituting a state-wide tender system regulating the movement of crude oil and all its products. The system for crude oil transportation is similar to that established in the East Texas field in February, 1932, and the order governing crude oil products is of the same general nature as that adopted by the commission in August, 1934, governing products processed in East Texas.

Under the new ruling a shipper must obtain a commission permit before any crude oil product can be moved from any field, refinery or topping plant in Texas. The order prescribes the form of application for a permit, and prohibits all transportation, whether by pipe line, rail, truck or otherwise, of crude oil products without the transporter first being furnished an approved copy of the commission's permit.

The new crude oil tender is state-wide in scope, except that it does not apply to the East Texas field, where such a system already is in force. Its provisions establish a system whereby oil, from the time it is produced in Texas to its final delivery to a refinery or consignee, is registered with the commission.

The order became effective December 10. Offices for issuing tenders for intrastate shipments have been established at Kilgore, Dallas, Corpus Christi, Refugio, San Antonio, Wichita Falls, Abilene, Midland, Houston and Pampa.

●

Governors of Oil States Meet

Governors and governors-elect, as well as other representatives of the various oil-producing states, met in Ponca City, Oklahoma, December 3, at the invitation of Governor-elect E. W. Marland, of Oklahoma, to consider an interstate compact for the control of the oil industry. Members of the Code Committee also were in attendance, although they did not enter into any of the discussion. Except for Governor Landon of Kansas those at the conference expressed opposition to federal control. Governor Landon took the position that an interstate compact is desirable, but believes federal control would be necessary between the time of the expiration of the oil code and the time when such a compact would bcome effective.

Continuance of Section 9-C of the NRA oil code, which gives the federal government authority to stop the running of illegally-produced oil in interstate commerce, was favored by the conference. Approval also was given to a recommendation that the President be empowered by Congress to limit imports of crude oil or refined products to a quantity that would protect consumers and producers of the United States.

Four resolutions were presented by governors and representatives of Texas, Oklahoma, New Mexico and Kansas. These resolutions were the personal sentiments of the representatives, and will be studied by the governors of all oil-producing states in the country. On January 3 another conference will be held at Ponca City, at which time it is possible an interstate compact may be drafted for presentation to the different states and to Congress.

●

Kentucky Protests Allowable

Kentucky oil producers have registered a protest against the national oil administration's allowable of 11,000 bbl. per day. It is stated that Kentucky, on a 11,000-bbl. allowable, cannot supply its own needs and must import from other states. Inasmuch as the state is capable of producing but 15,000 to 18,000 bbl. a day, and virtually all the wells are strippers that fall off rapidly, operators feel they should be permitted to pump them to capacity. It is pointed out that the increased production would have little effect on the national situation and oil-field workers in the state would be greatly benefited.

●

Wilshire Case Comes Up In January

The suit of the government against the Wilshire Oil Company of California, which will test the right of federal authorities to fix an oil production quota for California, will be brought to trial in January, it is now indicated. Counsel for both the government and the Wilshire Company have advised Federal Judge Paul McCormick that they will be ready early in the month. Judge McCormick has not set the exact date for trial, but has stated, that owing to its great importance, he would make way for it at the earliest possible moment.

After arguments have been concluded and affidavits filed, Judge McCormick said he would take under advisement the government's plea for a temporary injunction restraining the group from producing its wells in excess of quotas established for California by the federal administration at Washington, D. C., and specifically fixed by the operators' committee. In an affidavit, the Wilshire Oil Company alleges it is now operating under a 40 per cent curtailment.

●

Panama-Amazon Case Before High Court

On December 10 argument started on the Panama-Amazon oil code case before the United States Supreme Court. This case, which is not only of importance to the oil industry, but to every industry operating under the NRA, will test the validity of the National Recovery Act, as well as the oil code. Plaintiffs in the consolidated cases, who are East Texas producers and refiners, question the validity of the oil code, some of the oil administrator's regulations and sub-section 9 of the NRA which permits regulation of interstate oil shipments by the federal government.

Last February the complainants won their case in a Federal District Court, but later lost when the government appealed to the Fifth Circuit Court of Appeals, and they are now appealing to the United States Supreme Court.

It is not thought that an opinion will be given in the case before the middle of February.

●

Drop in Pennsylvania Crude Price

All grades of Pennsylvania crude oil were reduced 25c a bbl. December 6, the prices being as follows: Bradford-Alleghany, $2.05; middle district, $1.91 to $1.97; southwestern Pennsylvania, $1.72; Eureka, $1.67, and Buckeye, $1.57. A previous cut amounting to 25c had been made on November 6.

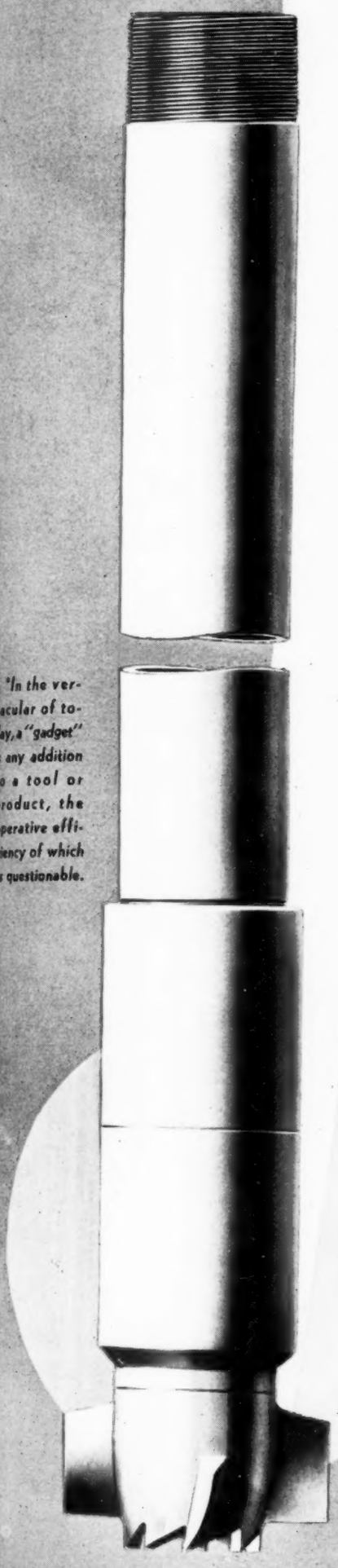
Corning grade crude was unchanged at $1.52 a barrel.

The 25c reduction also applied to the Cabio Creek, Bradford Hollow, and Kelly Creek grades in West Virginia, the price of each being $1.67.

●

Strappage Allowance Rescinded

Late in November the Texas Railroad Commission rescinded an allowance of 1 per cent which pipe lines were permitted to deduct from crude oil runs for strappage. Rule nine of the commission was amended and now requires that all oil shall be measured on 100 per cent capacity tank tables, whereas the measurement under the previout ruling was 99 per cent. In making the new ruling the commission stated that the allowance was initiated in the early period of oil development when measurement of wooden storage tanks was inaccurate.



Gadgets vs. Safety in a core drill

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In the selection of a core drill do you give sufficient consideration to the factor of safety? Recently there has been a marked tendency toward the introduction of "gadgets"* in mechanical devices... gadgets which may or may not add to the value of the tool. When such a gadget in a core drill tends to weaken it, or sacrifice safety in any degree, it ceases to be a harmless addition thereto and immediately becomes a definite menace to the safety of the entire drilling procedure.

Safety is eminently essential in coring operations. With full knowledge of its importance, Elliott has steadfastly refused to incorporate any features in the design or construction of Elliott Core Drills that would sacrifice the high factor of safety essential in coring service.

Elliott records of recovery are unsurpassed in the service for which they are intended. Of equal importance is the fact that Elliott Core Drills are as safe to run in the hole as correct design, fine materials, and precision manufacture, with a background of more than twelve years of intensive coring and core drill manufacturing experience, can make them.

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LATEST ACTIVITIES IN THE OIL FIELDS

SEVERAL new pools were discovered in Texas during the month. When the Magnolia Petroleum Company brought in its No. 1 Emil Labbe, a wildcat gasser in Duval County, nine miles east of the Eagle Hill field, another new Jackson trend field was believed opened in the county. The well is producing from sand at a total depth of 2460 feet.

In Harris County a new gas field, which has possibilities of developing into an oil field, was discovered. C. B. Bunte's No. 1 Laura Lackner, drilled to a total depth of 7695 ft., is a half mile north of Eureka. When the well was brought in it flowed wash water, gas, and a trace of distillate with a slight showing of oil. Later it made 40 to 50 bbl. of distillate per day.

Calhoun County was given its first production with the completion of the Steen Drilling Company's No. 1 Stanzel as a large gasser flowing approximately five bbl. of 52-gravity oil or distillate from sand at 6145-68 feet. The well is one mile west of Port Lavaca.

A wildcat of the Heep Oil Corporation, No. 4 Welder, three-fourths of a mile east and south of the Sinton field, San Patricio County, showed for a possible producer at approximately 5900 feet. The well showed considerable 33-gravity oil under pressure.

●

Oil has been discovered within the city limits of Cut Bank, Montana. R. C. Jefferies' No. 1 Lukens, in the northeastern part of the town, is producing from the Lower Cut Bank sand at a total depth of 2979 feet. When brought in the well was estimated as good for 150 bbl. daily on the pump, but it has exceeded expectations. The well swabbed 328 bbl. initial flow and is pumping at the rate of 175 bbl. a day.

●

The oil boundary of Kansas has been pushed westward into Scott County by the Atlantic Oil Producing Company's No. 1 Mary E. Vaniman, estimated as a 300-bbl. per day producer. Oil was found in a chat streak in the top of the Mississippi lime at 4680 ft., and the well was deepened to 4682 feet. The oil tests 26-gravity. The wildcat is 14 miles southwest of Scott City.

The outstanding test of recent days in Oklahoma was that of the Sinclair-Prairie Oil Company (No. 1 Cawood), which extended the Lucien pool one mile to the east. The Viola lime was found at 4970 to 4983 ft. and the well blew in making from 12,000,000 to 15,000,000 cu. ft. of gas. It was closed in, and when reopened for gauging flowed oil.

●

A new field has been discovered on the Gulf Coast of Louisiana. The Texas Company's No. 4 State Four Isle, brought in as a producer in Terrebonne Parish, made an initial production of 2230 bbl. of 44.5-gravity oil daily. The well was drilled to a total depth of 5639 ft. with the producing sand topped at 5611 feet.

●

Two large flowing wells recently completed at the 3360-ft. level in the Rainbow City (Champagnolle) field, Union County, Arkansas, have resulted in considerable activity in that area. The field has been producing for six years from a sand at 3200 feet. The new wells are producing from a new horizon in the red bed series of the lower Cretaceous, and the discoveries have brought about a drilling spurt. During one week recently 12 locations were staked.

●

The Canifornia Company's No. 1 Holst, Albany County, southeastern Wyoming, was brought in with an initial production of 500 bbl. of oil daily from a total depth of 3340 feet. This discovery well proves up the Quealy Dome and is said to be the first found in the Rocky Mountain district through geophysical work.

●

The Venice, California, field has been extended approximately one-half mile to the south with the completion of Charles W. Fourl's No. 1 Fourl for an initial production of 4600 bbl. of 24.6-gravity oil. Subsequently several other tests were started in the extension area.

AVERAGE CRUDE OIL PRICES

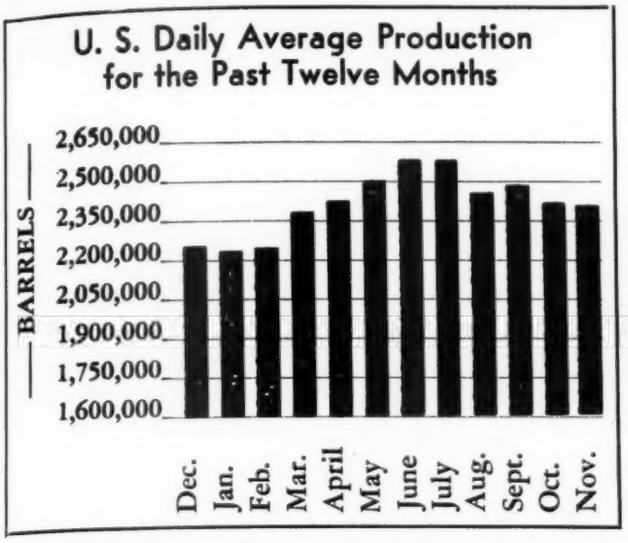
California	
Playa Del Rey	$ .90
Coalinga	.81
Signal Hill	1.12
Montana	1.35
Wyoming	1.00
Colorado	1.00
New Mexico	.75
Texas	
North Central	.95
Panhandle	.83
West Texas	.70-.75
Gulf Coast	1.04
Darst Creek	.87
East Texas	1.00
Kansas	1.00
Oklahoma	1.00
Arkansas	.70
Louisiana	
North Louisiana	$ .95
Gulf Coast	1.04
Illinois	1.13
Kentucky	1.08
Indiana	1.12
Ohio	
Lima	1.30
Michigan	1.02
Pennsylvania	
Bradford	2.05
Southwest	1.72
Eureka	1.67
Buckeye	1.57
Corning	1.32
West Virginia	1.67
Canada	2.10-2.17

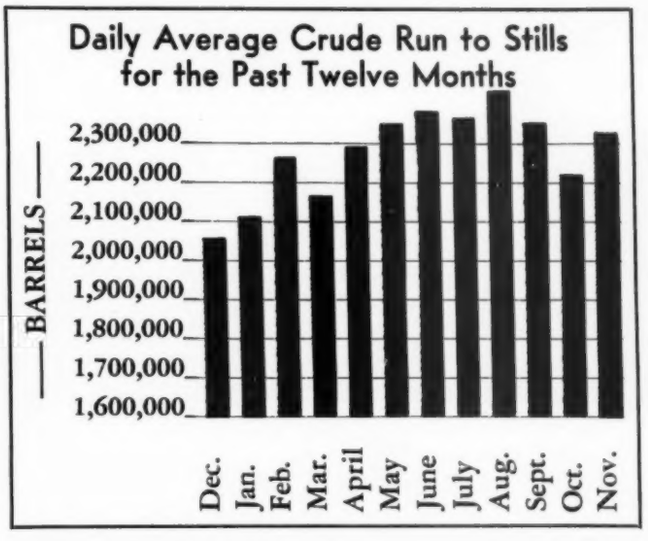
DAILY AVERAGE CRUDE OIL PRODUCTION

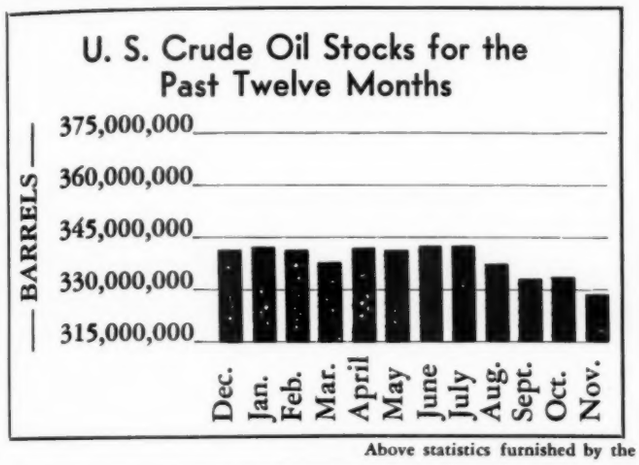
(Figures in barrels)

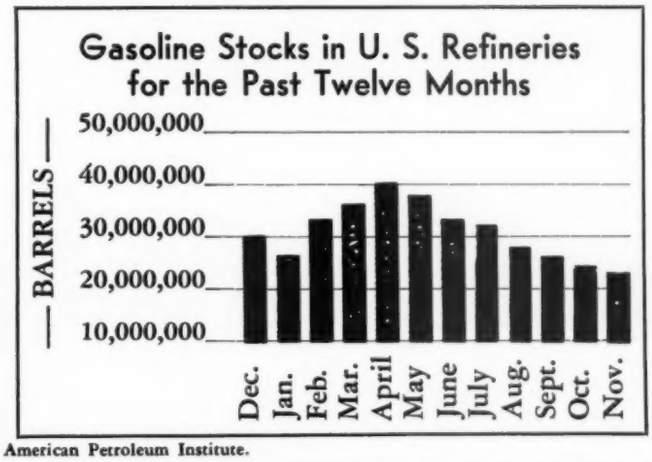
Furnished by A.P.I.

	Federal Agency Allowable Effective Nov. 1	Week Ended Dec. 1, 1934	Week Ended Nov. 3 1934	Week Ended Dec. 2, 1933
Oklahoma	459,300	463,600	400,450	421,750
Kansas	125,000	127,300	120,000	114,700
Panhandle Texas		59,800	62,050	40,050
North Texas		54,400	56,900	57,250
West Central Texas		27,500	27,600	23,950
West Texas		138,800	140,750	121,300
East Central Texas		43,100	42,950	43,300
East Texas		413,200	405,800	397,150
Conroe		37,900	38,200	51,600
Southwest Texas		61,150	60,050	43,550
Coastal Texas (Not incl. Conroe)		126,100	125,250	101,050
TOTAL TEXAS	957,300	961,950	959,550	879,200
North Louisiana		24,000	24,150	26,300
Coastal Louisiana		82,850	81,450	47,500
TOTAL LOUISIANA	90,000	106,850	105,600	73,800
Arkansas	30,000	31,150	30,250	32,250
Eastern (Not incl. Michigan)	96,000	108,550	103,050	97,200
Michigan	29,000	26,900	27,650	28,450
Wyoming	33,200	36,650	32,650	28,950
Montana	8,500	11,900	11,550	7,000
Colorado	3,000	3,200	3,050	2,600
TOTAL RK. MT. ST.	44,700	51,750	47,250	38,550
New Mexico	47,000	45,750	45,500	42,150
California	462,000	448,960	446,100	467,000
TOTAL U. S.	2,340,300	2,372,700	2,285,400	2,195,050









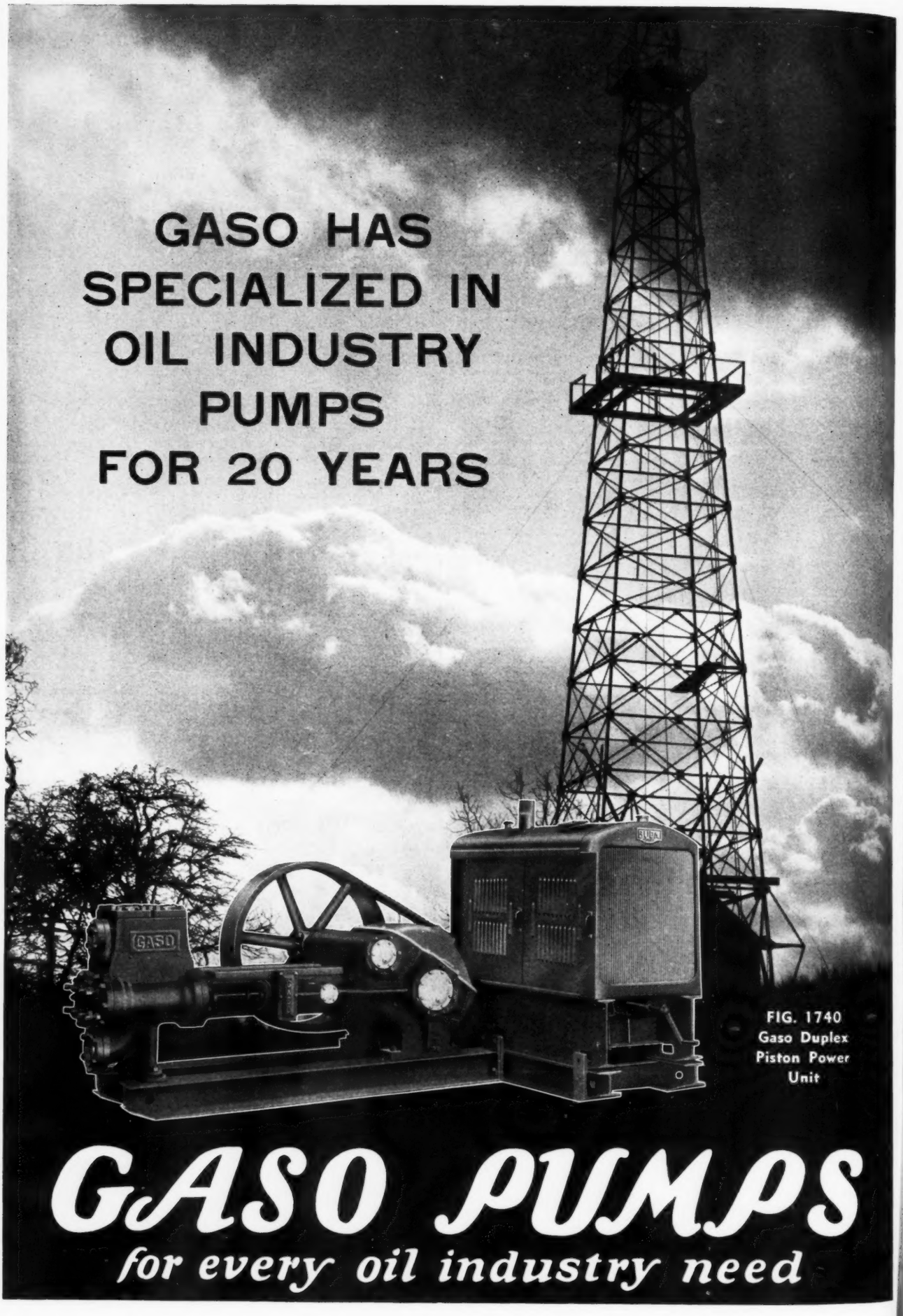
Above statistics furnished by the American Petroleum Institute.

Summarized Operations in Active Fields for November, 1934

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
Texas								
East Texas	255	250	26	56	3600	2	40	Rotary
Duval County	37	26	8	12	2300	2	22	Rotary
Archer County	80	58	16	66	660–1800	1 or 2	40	Rot.-Cab.
Conroe	5	4	0	2	3000–7400	3 or 4	40	Rotary
Refugio County	10	7	2	5	5200	2	38	Rotary
Oklahoma								
Oklahoma City	1	1	5	25	6500	3	39	Rotary
Osage County	31	26	20	54	380–2850	2	37.5–40	Rot.-Cab.
Kansas								
McPherson County	9	7	5	24	2900–4300	2	38	Rot.-Cab.
Ellsworth Arch	40	30	15	58	3300	4	37	Cable
California								
Kettleman Hills	2	2	6	28	8300	3 or 4	40	Rotary
Long Beach	7	7	14	21	7000	3	26	Rotary

Field Activities by States for November, 1934

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1933 (In Barrels)
	November	October	November	October	November	October	November	October	November	October	
Arkansas	8	7	3	3	15	8	7	6	34	37	11,682,100
California	65	42	62	38	70	30	64	52	208	198	173,126,800
Colorado	3	6	2	0	....	....	5	6	33	34	954,900
Illinois	....	....	....	....	....	....	0	3	14	12	4,250,000
Indiana	28	....	18	....	....	....	2	2	55	42	730,000
Kansas	79	76	56	52	119	81	48	33	196	161	41,927,700
Kentucky	43	57	28	41	....	....	2	3	17	41	4,610,000
Louisiana	69	67	43	44	54	66	63	55	174	180	24,487,800
Michigan	44	31	27	21	34	25	96	104	151	127	7,790,800
Mississippi	....	5	....	0	....	....	4	4	12	13	Gas. Prod.
Montana	14	14	9	12	....	....	8	15	56	78	2,128,700
New Mexico	20	9	16	9	....	....	10	9	69	76	13,086,600
New York	....	....	....	....	....	....	2	1	9	10	3,150,000
Ohio	107	113	85	87	....	....	59	44	201	208	4,300,000
Oklahoma	160	148	115	97	213	167	63	85	478	451	181,133,200
Pennsylvania	14	30	11	26	....	....	60	15	220	43	12,690,000
Texas	742	756	546	575	887	667	375	277	970	1063	396,993,600
West Virginia	40	56	29	46	....	....	25	34	95	79	3,825,000
Wyoming	8	3	6	1	....	....	8	8	82	67	11,211,000
Total	1444	1420	1056	1052	1492	1083	901	756	3074	2920	898,078,200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PROGRESS OF MAJOR PIPE LINE WORK

A 145-mile 3-in. oil line is being constructed in Persia from the Naft-i-Shah oil field to Kermanshah, where the Anglo-Persian Oil Company is erecting a refinery. The line is expected to be completed some time during the summer of 1935. It is being electrically welded and tested to a pressure of 2300 lb. per sq. inch. Since the country traversed is rugged and broken, trenching machinery is impractical and trenches are being dug by manual labor. The altitude of the country crossed varies from 500 ft. to 5000 ft., being 4000 ft. at the terminus where the refinery is situated. Winter and summer temperatures fluctuate over an equally wide range, from as low as zero in winter to as high as 120 deg. fahr. in the summer. The pipe is being buried to a depth of two ft. and is first felt-wrapped and coated with bitumen.

Four pump stations are being constructed. The No. 1 station, which will be steam-driven, will have three horizontal high-pressure reciprocating pumps that will operate up to as high as 1500 lb. pressure. The other stations will be Diesel-powered, each having three engines of 45 b.hp. The stations also will be equipped with Diesel generating sets for lighting and fire extinguishing purposes.

●

The new gas booster station under construction by the Kettleman North Dome Association in the Kettleman Hills field of California is scheduled for completion in December. The station will have six compressor units capable of handling 12,000,000 cu. ft. of gas daily, and will increase Kenda's handling capacity in the North Dome to 22,000,000 cu. ft. daily. A year ago the Kettleman North Dome Association constructed its first compressor station in the field, a five-unit plant capable of handling 10,000,000 cu. ft. of gas daily. The stations will boost gas from the field to the association's centrally situated tank farm.

●

A natural gas distribution system is to be constructed in Wichita Falls, Texas, with a pipe line being laid to a producing field not yet decided upon, according to an announcement by W. S. Cooper of Kansas City, president of the Wichita Falls Gas Company, which company already has purchased 35 miles of pipe for the project. Construction work likely will begin January 1, Mr. Cooper says. The Wichita Falls Gas Company has been granted a franchise for distribution of gas in Wichita Falls for domestic consumption.

●

The American-Michigan Pipe Line Company's 55-mile 8-in. natural gas line from Austin Township, Mecosta County, Pool to Muskegon, Michigan, has been completed, and the line tested under pressure of 400 lb. per sq. inch. A system of transmission lines within the city limits, of 12-in. pipe, also has been completed. The changeover in Muskegon and Muskegon Heights from manufactured to natural gas was made by districts, and covered a period of three weeks. This is the longest natural gas line in the state of Michigan.

●

The 11½-mile pipe line of the Southern Ontario Gas Company to deliver gas from F. H. Stover and Son's No. 1 in Dover Township, Kent County, Ontario, to the company's trunk line to the south, has been completed. Where the line crosses the River Thames it was necessary to lay the pipe seven ft. beneath the river bed, in order to meet the requirements of the federal public works department.

●

The United Gas Company on November 29 completed the construction of an overhead pipe line crossing at the edge of Fort Worth, Texas. The crossing, a 60-ft. span of 12¾-in. pipe, is over an underpass where the Cotton Belt Railroad crosses a new highway.

●

A 55-mile 8-in. gas line costing approximately $1,000,000 will be laid from the Dawn field to London, Ontario, if a proposal submitted by the City Gas Company to the city council of London is approved by that body. The city is using artificial gas at present. The Dawn field has a total of 20 producing gas wells.

●

The Apache Gas Company of Perry, Oklahoma, has completed an 8-in. pipe line from the Perry gas field to the Polo oil field, ten miles to the northwest. A portion of the company's line extending north of Perry was taken up for use in constructing the new line.

●

The Texas Gas Utilities Company is to lay a 32-mile line from the Rycade field in Maverick County, Texas, to connect with its line that extends into the Winter Garden district. The tie-in will be made at a point four miles south of La Pryor. The same company recently constructed a 4-in. line from Uvalde, Texas, to the Zavala County wells, a distance of 13 miles.

●

A 14-mile 6-in. pipe line has been constructed from the Apex Gasoline Company's new plant in Porter Township, Midland County, Michigan, to the Dow Chemical Company's plant at Midland. The Apex company is under contract to supply the Dow organization with 10,000,000 cu. ft. of residue gas daily. The line was laid by the Franklin Tool Company of Mount Pleasant, with Jene Harper in charge of the construction work.

●

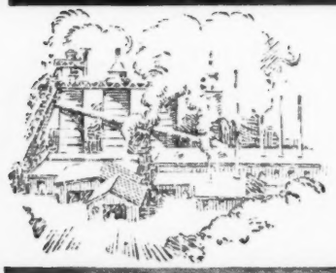
Otto Woods, Ben King, and others interested in the King-Woods Oil Company, have organized the Woodsfield Pipe Line Company and will construct pipe line facilities for handling crude oil from the Sam Fordyce field in southwest Texas. A 14-car loading rack already has been completed. Woods is the discoverer of the field.

●

The Stanolind Pipe Line Company plans to lay a 40-mile 8-in. pipe line to take oil from the Fitts pool in southern Pontotoc County, Oklahoma. The line will extend from the Fitts area to Pauls Valley, Oklahoma, and there will tie into the company's trunk line that runs from Texas City, Texas, to Chicago. While the Stanolind already has a 4-in. line serving the field, a new one is needed to care for the growing production of the pool, officials of the company have stated.

●

The Kentucky Public Service Corporation has been issued a certificate of necessity and convenience by the State Public Service Commission, authorizing it to lay a 78-mile gas line in Hardin and Barren counties.



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THE MONTH'S ACTIVITIES IN REFINING

Per Cent Refining Capacity Operated

Eastern Division, 73.5 per cent **Central Division, 63.7 per cent** **Western Division, 51.9 per cent**

THE Standard Oil Company of California has under way extensive construction programs at its Richmond and El Segundo refineries in California. Expenditures for this improvement work are expected to aggregate $2,000,000. Wharf repairs and extensions, increased crude oil receiving facilities, crude oil distillation equipment, and lubricating oil refining and treating plants are included in the expansion program. A combination atmospheric and vacuum unit is under construction at Richmond that will be capable of feeding 21,000 bbl. of crude oil daily and producing a total of 11 closely fractionated streams varying from a light gasoline to a heavy lubricating distillate, as well as specification road oil, and asphalt bottoms. Under construction also is a special rerun unit for refining lubricating oils. It will have a feed capacity of 3500 bbl. per day.

A selective solvent plant also is being constructed at Richmond for treating lubricating oils. It will have a rated capacity of 2200 bbl. per day, based on finished oils. In addition to its treating facilities the unit will have a complete recovery system for reducing the loss of solvents.

Enlargement of crude oil handling facilities at the refinery also are contemplated. The facilities to be enlarged are those handling oil delivered by tankers and probably will include an additional berth at the wharf, a large crude oil delivery line to the shore, pump booster station, and discharge line system to the refinery tankage.

At the El Segundo refinery the Standard is electrifying its pumping equipment, improving its distillation facilities, and enlarging its means of receiving, as well as discharging, crude over the present submarine terminal.

All work is expected to be completed by the first of the year.

●

Should a bill recently introduced in the Senate become a law the Colombian government would be authorized to erect a refinery to exploit its crude oil royalties and petroleum obtained from other sources, says a report by Clarence C. Brooks, United States commercial attaché at Bogota. The proposed legislation would authorize the government to create an autonomous agency, under the direction of its ministry of industries, to carry on oil refining and marketing operations with budgetary funds of a special loan floated for the purpose of providing the capital required. Gasoline and oil sales would be subjected to the existing sales taxes now levied and collected on these products, and such profits as might accrue from the venture would revert to the state.

●

American Consul General Leslie E. Reed at Montevideo, Uruguay, reports that the ANCAP (Administracion Nacional de Combustibles, Alcohol y Portland) has accepted a bid for the construction of an oil refinery, work to start immediately and the refinery to begin operating in October, 1935. The bid accepted was that of Foster-Wheeler, Ltd., London, England, and is said to involve approximately 40,000,000 pesos, which also includes the right for cracking and the production of crude oil for ten years. Arrangements have been made to obtain the crude from the Lobitos Oilfields, Ltd., whose representative also acts for the Anglo-Ecuadorian Oil Fields, Ltd., and Foster-Wheeler, Ltd.

●

The new refinery of the Lobitos Oilfields, Ltd., which has been under construction at Ellesmere Port, England, for approximately a year, has been completed and put into operation. The refinery, one of the largest and most modern in England, is a compact full-range distillation unit. Benzine, kerosene, gas oil, lubricating oil, and bitumen can be processed in one operation, one processing benzine, kerosene and gas oil, the other picking up the residue from the first and producing lubricating oils and bitumen. The two sections can be operated simultaneously or independently.

●

The Comet Oil Refineries, Ltd., are constructing a refinery at Point-aux-Trembles, on the St. Lawrence River near Montreal. A Dubbs cracking unit having a capacity of 2000 bbl. per day will be installed. The pipe still distillation unit will be of 3000-bbl. daily capacity.

Crude Runs to Stills, Gasoline and Gas and Fuel Oil Stocks, Week Ending December 1, 1934

A.P.I. Figures
(Figures in Barrels of 42 Gallons Each)

DISTRICT	Per Cent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Per Cent Operated of Total Capacity Reporting	Total Motor Fuel Stocks Thousands of Bbl.	Gas and Fuel Oil Stocks Thousands of Bbl.
East Coast	100.0	467,000	80.2	11,848	14,715
Appalachian	93.3	93,000	66.4	1,694	1,669
Ind., Ill., Ky.	94.6	312,000	73.9	6,446	5,607
Okla., Kans., Mo.	83.7	215,000	55.7	3,654	3,927
Inland Texas	47.6	89,000	53.3	1,075	1,175
Texas Gulf	97.5	483,000	87.5	4,155	11,308
La. Gulf	96.4	112,000	69.1	1,104	4,375
No. Louisiana-Ark.	83.7	41,000	53.2	209	547
Rocky Mountain	66.7	38,000	59.4	498	647
California	96.9	364,000	44.3	10,148	69,469
TOTALS WEEK:					
December 1, 1934	89.7	2,214,000	65.6	40,831	113,979
November 24, 1934	89.7	2,379,000	70.5	40,206	113,262

» » THE PETROLEUM ENG AWARDS ANNUALLY for E

Separate Award for Each of Production and Drilling, Refining, Natural Gasoline Manufacturing, and Oil and Gas Transportation Divisions

In keeping with its policy of fostering the origination and development of efficient operating methods, *The Petroleum Engineer,* beginning with the year 1935, will make an annual award in each of the production and drilling, refining, natural gasoline manufacturing, and oil and gas transportation divisions of the petroleum industry.

The award, a handsome bronze plaque (illustrated on the opposite page), will go each year to the person who either originates or contributes most to the development of a method that is likely to prove of greatest permanent value to each division.

The judges will be selected by the editor of *The Petroleum Engineer* from among executives or high officials actively engaged in an operating capacity and considered outstanding authorities in their several divisions. Selection of winners will be entrusted entirely to the judges. Members of *The Petroleum Engineer* staff will neither be eligible for an award nor have a voice in the selection of any individual to whom an award shall go. The judges will use as the basis for their decision the method articles that have been published in *The Petroleum Engineer* during the year for which the awards are made.

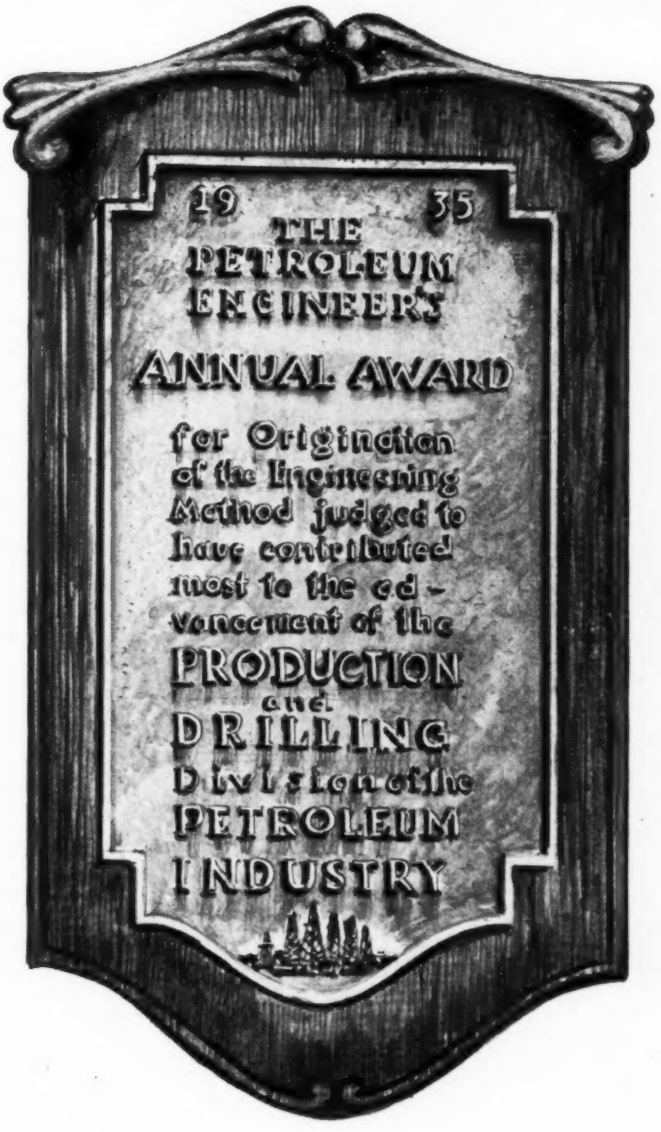
Judges, five from each division mentioned, will remain permanent and will be announced in an early issue of this magazine. The period covered by each award is the calendar year, January to December, inclusive.

At the time of announcing permanent judges, complete details of these awards will be published.

Winners in all divisions will be announced in the first possible issue after decision of judges.

ENGINEER TO MAKE FOUR for ENGINEERING METHODS

The plaque sketched at the right, although it designates the Production and Drilling division, is typical of the award to be given in each of the other three divisions. Name of the recipient, of course, will appear on each.


19 35
THE PETROLEUM ENGINEERS
ANNUAL AWARD
for Origination of the Engineering Method judged to have contributed most to the advancement of the
PRODUCTION and DRILLING Division of the PETROLEUM INDUSTRY

Size of the actual plaques to be awarded will be approximately twice the dimensions of the above illustration and mounted on hand-carved walnut.

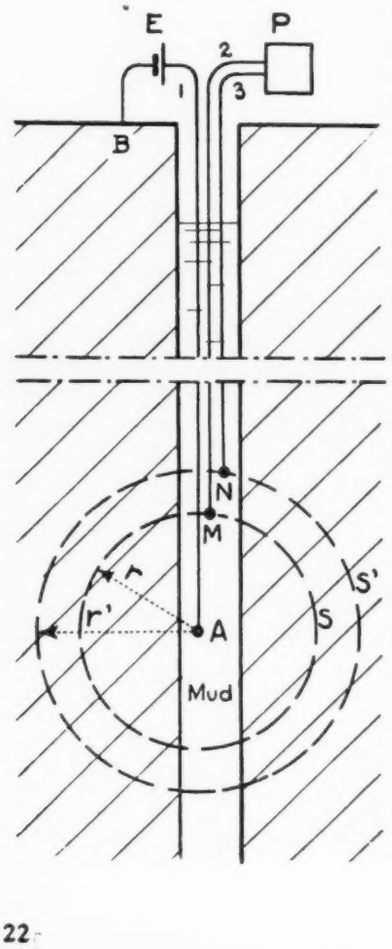
By
A. C. RUBEL
Manager of
Field Operations, Union
Oil Co. of California

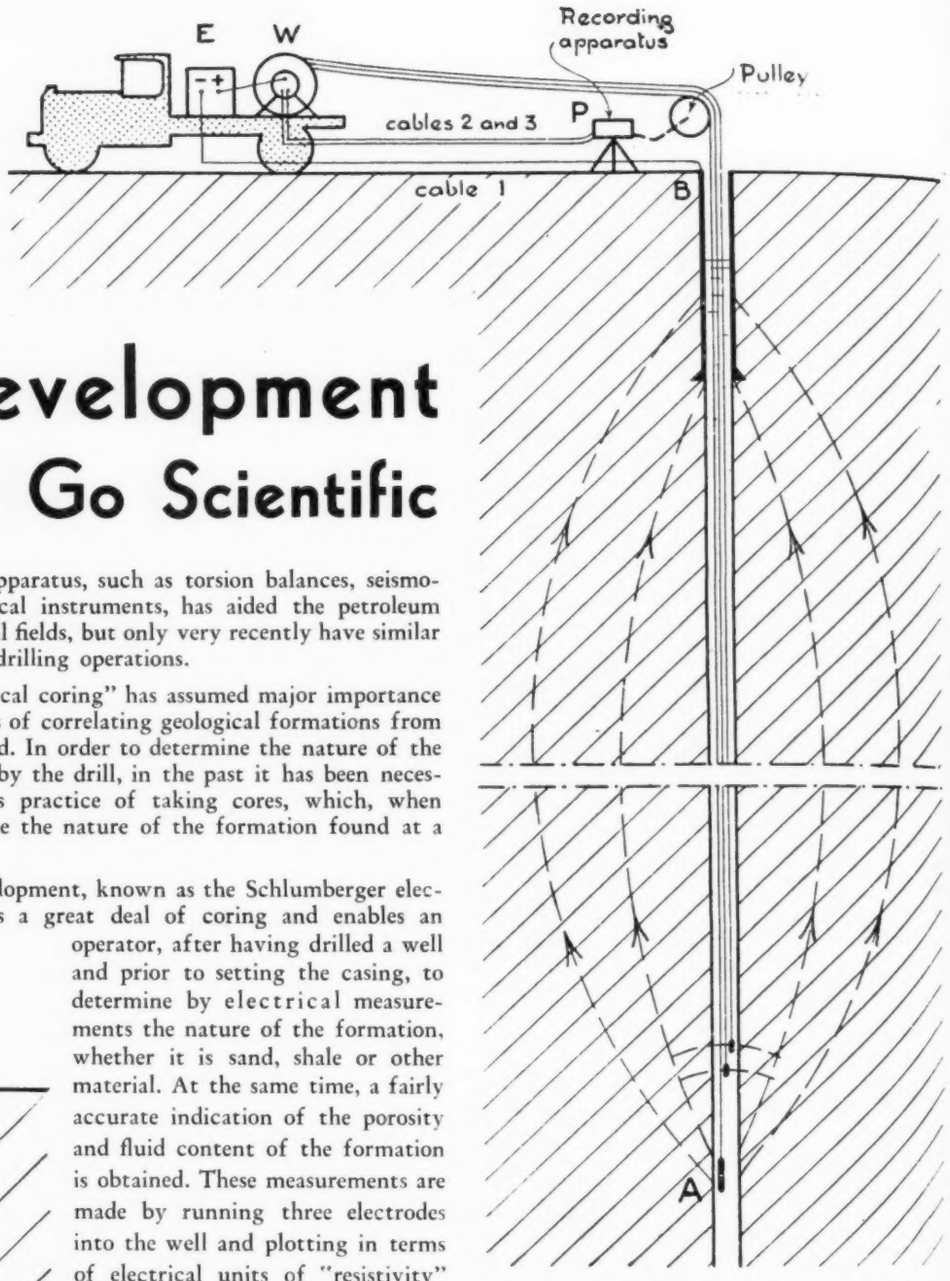
Field Development
Operations Go Scientific

FOR many years scientific apparatus, such as torsion balances, seismographs and other geophysical instruments, has aided the petroleum geologist in his search for new oil fields, but only very recently have similar means been adopted in actual drilling operations.

In the past two years "electrical coring" has assumed major importance in drilling operations as a means of correlating geological formations from well to well in the same oil field. In order to determine the nature of the subsurface material penetrated by the drill, in the past it has been necessary to resort to the laborious practice of taking cores, which, when brought to the surface, indicate the nature of the formation found at a known depth.

A comparatively recent development, known as the Schlumberger electrical coring device, eliminates a great deal of coring and enables an operator, after having drilled a well and prior to setting the casing, to determine by electrical measurements the nature of the formation, whether it is sand, shale or other material. At the same time, a fairly accurate indication of the porosity and fluid content of the formation is obtained. These measurements are made by running three electrodes into the well and plotting in terms of electrical units of "resistivity" and "voltage" two synchronized curves that indicate, respectively, the type of formation and porosity. Such curves in any given oil field, when compared with a cored section from one of the first wells, enables





Cross section of method of setting up instruments for resistivity measurements. E — battery; W — winch carrying insulated cables; P — potentiometer; B — ground for cable I; A — one of the three electrodes.

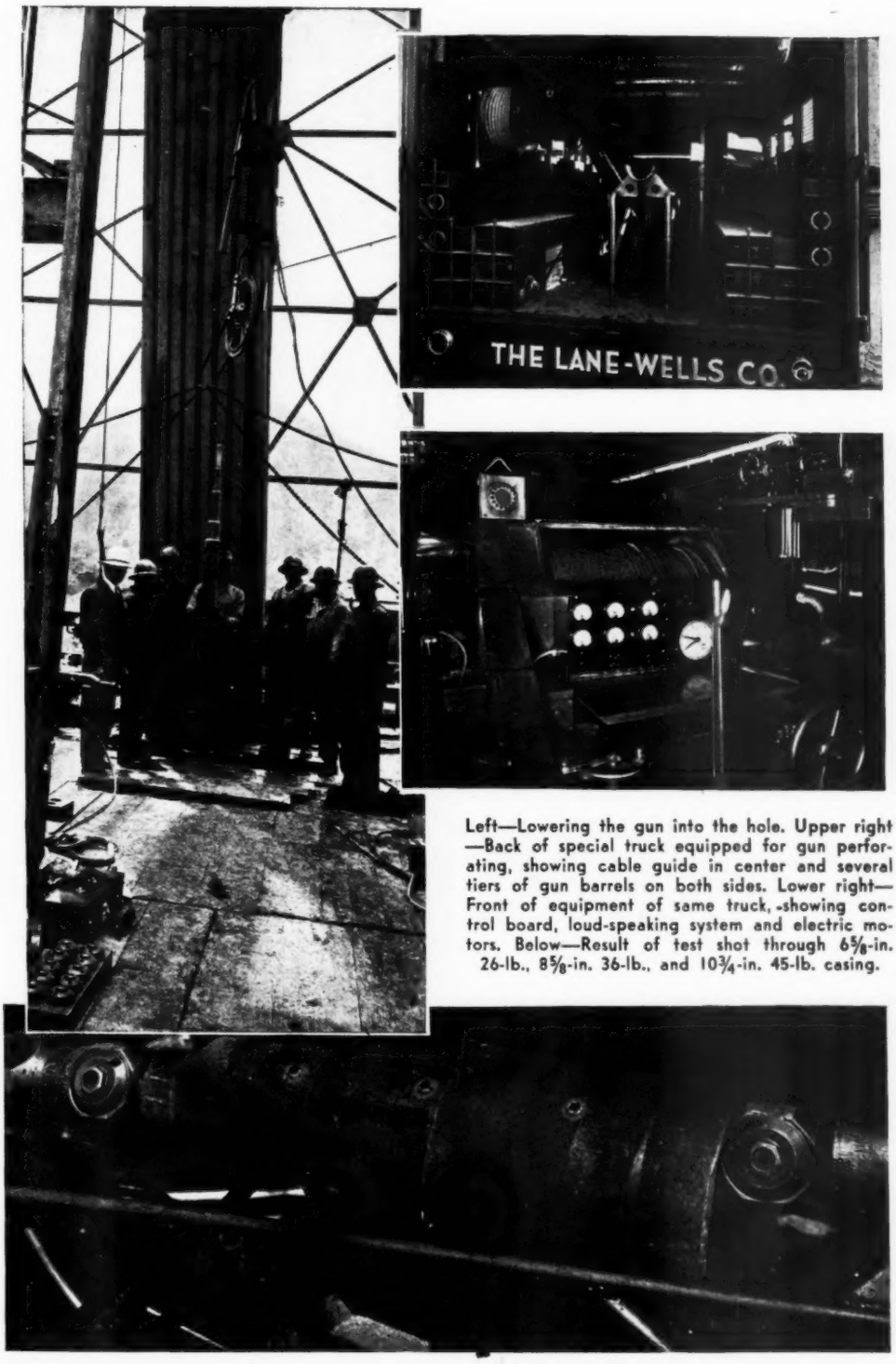
The device usually employed for taking resistivity measurements is shown at the left. It comprises three insulated cables, 1, 2 and 3 (see illustration above), which are lowered into the well. Three electrodes, A, M and N, are attached to the cables, which dip into the water or mud filling the hole. Distances AM (r) and AN (r') are from 10 to 20 times the diameter of the hole. Electrode A is used to send the current into the ground, and electrodes M and N to measure the difference of potential caused between these two points by passage of the current through the ground. To cause the current to flow into the ground (illustration above), electrode A is connected with cable 1 to one pole of battery E, the other pole being grounded to any given earth contact B—frequently the casing. To measure the differences of potential between M and N, these electrodes are connected by cables 2 and 3 to terminals of the potentiometer P. Knowing the distances, r and r', the intensity of the current passed through the ground, and the difference of potential voltage between M and N (as measured by the potentiometer), the average resistivity of the ground in the region of AMN can be calculated.

the operator to determine, with a surprising degree of accuracy, the position of sand and shale bodies without further coring other than to check the electrical readings. The device is very quickly and economically run in a well, and does much to speed up, and reduce the cost of, drilling operations. Plotting of the curves is done automatically, as the electrodes are lowered down the well.

An excellent example of how the findings of the electrical coring device are plotted in composite form for an oil field is pictured in an accompanying chart. The curves shown are those taken from actual operations in the Dominguez oil field, California, by the Union Oil Company. The line to the left denotes the "resistance curve," whereas the line to the right of the center multi-divided bar is the "porosity curve." High resistance is recorded by the curve swinging to the extreme left; conversely, high porosity is recorded by the curve swinging to the extreme right. In reading the chart both lines must be taken at the same well depth. Generally speaking, shale formation is indicated by low porosity and relatively high resistivity; sand formation, either with or without oil content, is indicated by high porosity and relatively high resistivity, while high porosity and low resistivity may be indicative of the presence of water. Other readings may mean the presence of any one of a number of other materials.

The bar between the lines is a charting of composite corings taken, in this instance, from the three wells to the right — the first well giving information down to its bottom, the next well from there to its own lower depth, and so on, to the lowest depth drilled in that field. The letters to the left of the "resistance curve" are comparable to a general filing system, for reference to specific formations. What is not shown in the chart is a paleontological bar similar to the bar shown, but divided according to paleontological analyses of actual cores taken from the well. This latter information is referred to by the operator, when comparing findings from electrical coring with those from actual coring.

In addition to determining the type of formation penetrated, it now has become very necessary either to drill a well without appreciable deviation from the vertical, or to determine accurately both the direction and degree of such deviation when it occurs. To accomplish this purpose, a number of instruments have been devised that are a regular part of drilling operations. The Union Oil Company, in its drilling operations, makes a practice of dropping a deviation instrument down the drill pipe after each run of the bit, in order to determine accurately the actual deviation from the vertical.



Left—Lowering the gun into the hole. Upper right—Back of special truck equipped for gun perforating, showing cable guide in center and several tiers of gun barrels on both sides. Lower right—Front of equipment of same truck, showing control board, loud-speaking system and electric motors. Below—Result of test shot through 6⅝-in. 26-lb., 8⅝-in. 36-lb., and 10¾-in. 45-lb. casing.

If, from these readings, it appears that the hole is drifting to any appreciable degree, immediate steps are taken to correct this drift and bring the hole back to vertical. It is interesting to note that, in the last five wells completed in Kettleman Hills to a depth of approximately 8600 ft., in no instance did the deviation from the vertical exceed two degrees, with a per-well average considerably under one degree.

Should the location of a well be such that deviation from

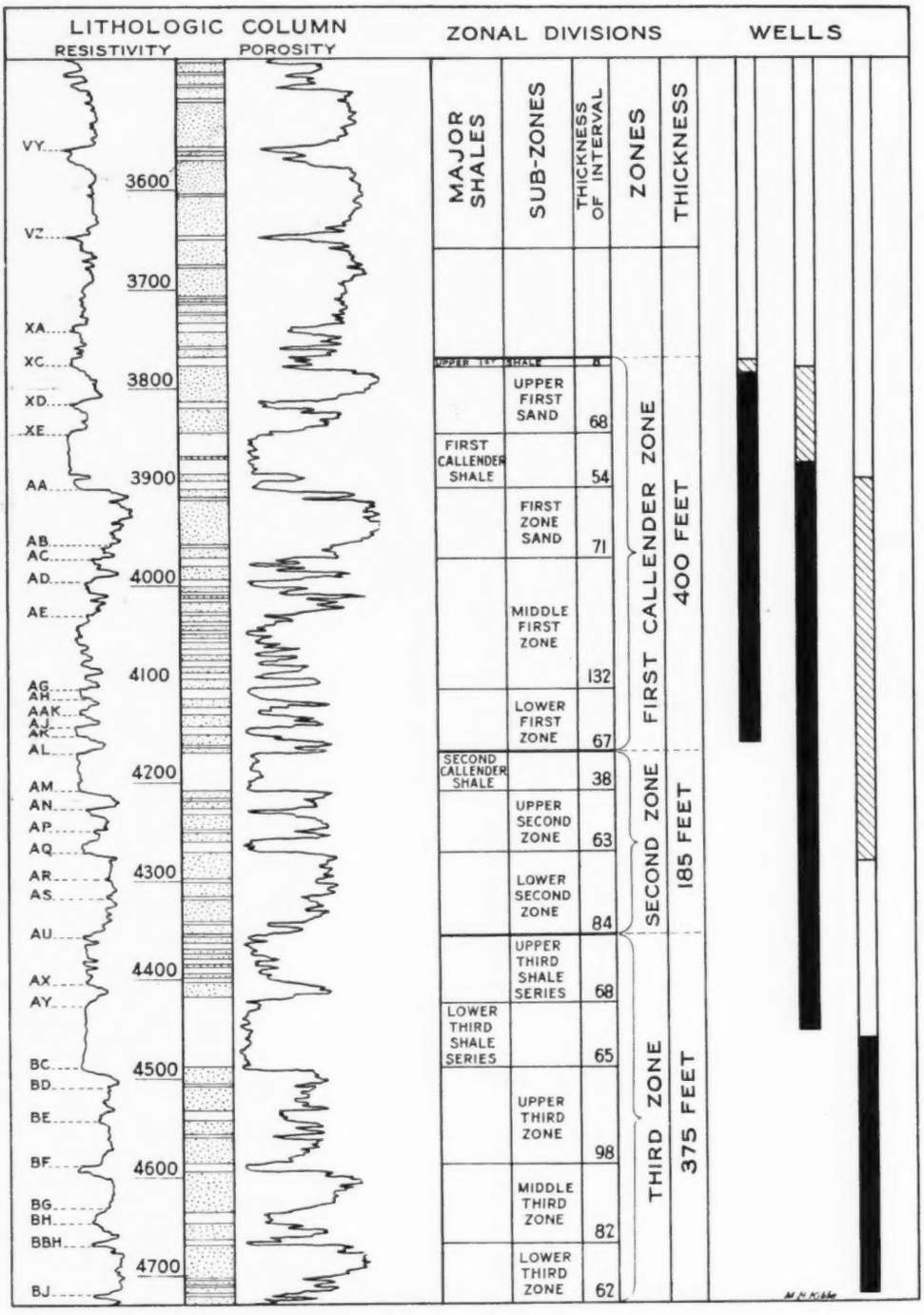


Chart shows a section of composite tabulation of "electrical corings" taken in the company's Dominguez oil field wells. From left to right—Letter index of formations; resistivity curve—high resistivity to the left, low to the right; composite bar showing sands (dotted portions) and shale as indicated by resistivity and porosity readings; porosity curve—high porosity to the right, low to the left; zonal divisions data and wells from which "electrical corings" were taken.

the vertical is of no importance, it is still necessary to know the direction of such deviation. For this purpose it is now possible to run directional surveys by means of a compass, which is automatically photographed at pre-determined intervals, by gyroscopic compasses operating on the same principle, or by actually measuring the orientation of the drill pipe joint by joint as it goes into the hole. A combination of inclination and direction determinations enables the operator to plot the course of his well in the same manner that a surveyor plots the course of an ordinary survey.

Another device that has contributed considerably in the promotion of scientific operation of an oil field, and which has effected noteworthy economy wherever used, is the "gun perforator." In the course of past operations it has been necessary many times to pass up oil sands of known or probable productive possibilities, in order to reach lower productive zones. These sands are excluded by one or more strings of casing cemented so as to form a bond with the formation.

With the depletion and subsequent abandonment of the lower zones, it becomes highly desirable again to open these upper sands to production. Until recently this has been a very difficult process, as it has been necessary either to perforate the casing by means of some mechanical tool, which drove a knife blade through the casing into the formation, or to assume the expense of redrilling the well. The former operation, while in itself relatively easy to perform, in many cases required so much jarring and working of the tool that the cement bond was completely destroyed, and water let in. With the small diameter of the average well and casing, it also has been difficult to procure a knife of sufficient length and strength to penetrate more than one string of casing and the cement bond with the formation.

A core, taken with a regular formation coring device, is being removed from core barrel in the upper photograph, while at the right is the core bit.

With the aid of these and other devices of similar nature that gradually are replacing guess-work in underground operations, the Union Oil Company is maintaining its strong position in the industry, with respect to the development and use of scientific instruments in drilling and production operations.

[This article is published by permission of the Union Oil *Bulletin* through the courtesy of the author.]

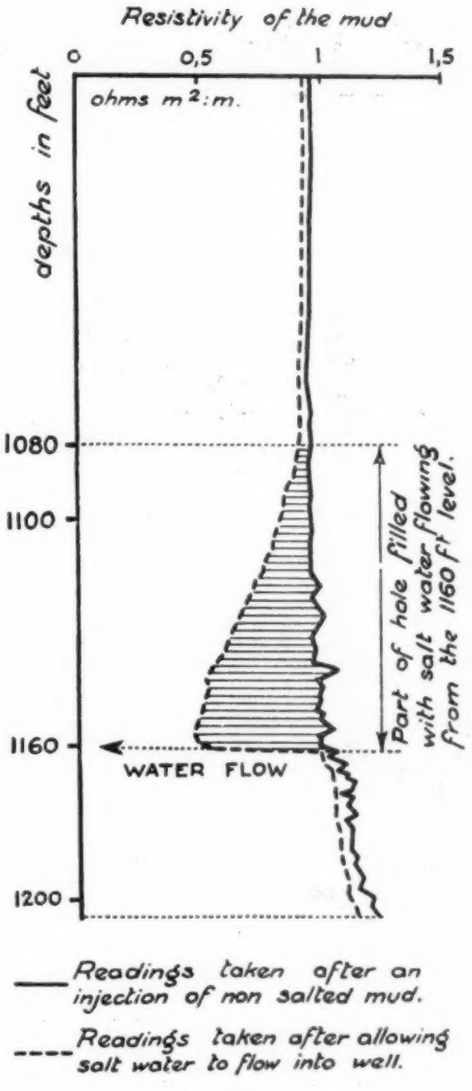
To overcome this condition and provide a rapid and effective method of perforating, an ingenious device known as the "gun perforator" has been developed, which is nothing more than a series of gun barrels, each loaded with a charge of high velocity powder and a 45-caliber steel bullet. The gun is lowered into the hole to the required point, and fired electrically from the surface. Numerous tests of this device have demonstrated its ability to penetrate as many as three strings of casing and still have sufficient velocity to open up the formation for a sufficient distance to permit fluid to enter.

There are three sizes of guns, the smallest carrying 12 shots per trip, the next carrying 15 shots, and the larger size carrying 10 shots. In each instance the gun is lowered to designated depth and the shots are fired one at a time and in diametrically opposite direction to the last shot. This eliminates all tendency to split the casing or crack the cement bond. As many as 180 holes were perforated recently at a depth of 3200 ft. in seven hours; in another case, 136 holes were made at 4400 ft. in 5 hours and 20 minutes.

The greatest enemy to production in California is water, which may occur either by encroachment due to the withdrawal of oil, by failure properly to protect producing sands with casing and cement, or by leaks in the water string due to failure, wear, and other causes. When water appears in any quantity in an oil well, the producing life of that well is seriously threatened and, unless immediate corrective measures are taken, the complete loss of the well may result.

To locate the entry of this water has been a very serious problem, but it has been solved to a great extent by the development of an electrical device known in the parlance of the oil field worker as a "water witch." Two methods are used for making these determinations. The first consists of washing the well with fresh water, so that all formation water is removed from the hole. The hole then is bailed to a point where the head of the encroaching water is sufficient to allow it to enter the well, then a pair of electrodes is run into the hole carrying a small current. Because of the relatively greater conductivity of salt water, as compared with fresh water, the point of entry of formation water is determined with extreme accuracy by noting the point of maximum increased flow of current between the electrodes.

The second method, also much favored by operators, is to convert that part of the well in the vicinity of the suspected water entry into a galvanic cell by the injection of certain electrolytes (a compound decomposable by an electric current). Two electrodes then are run into the fluid, causing a galvanic action that generates a current measured at the surface. The fluid head again is bailed, until formation water enters. The entrance of this water dilutes the electrolytes and correspondingly reduces the amount of galvanic action, the point of minimum action under this system indicating the point of entry of water.



Location of a water flow

Lone Star Completes New Te

THE Lone Star Gas System's first pipe line of major importance to be entirely electrically welded has just been completed, a 12-in., 70-mile line from the Long Lake gas field of southwestern Anderson County to its main line near Waco, Texas. This comprises part of a large expansion program contemplated by the Lone Star and rounds out that company's distribution facilities in Central Texas.

Clearance and grading of the right-of-way was begun on October 12 and laying of the line on October 17. Construction work was completed on December 15, a total of 65 days being consumed on the job. The A. F. Day Construction Company, Dallas, Texas, was the contracting firm. Several heavy rains delayed operations somewhat, but otherwise construction progressed uninterrupted.

With the exception of seven and one-half miles of new electric stitch-weld pipe, the pipe used on the trunk line was salvaged from unused portions of the Lone Star's system in southern Oklahoma and Texas. For the gathering system constructed in the Long Lake field three miles of new 10-in. pipe was laid.

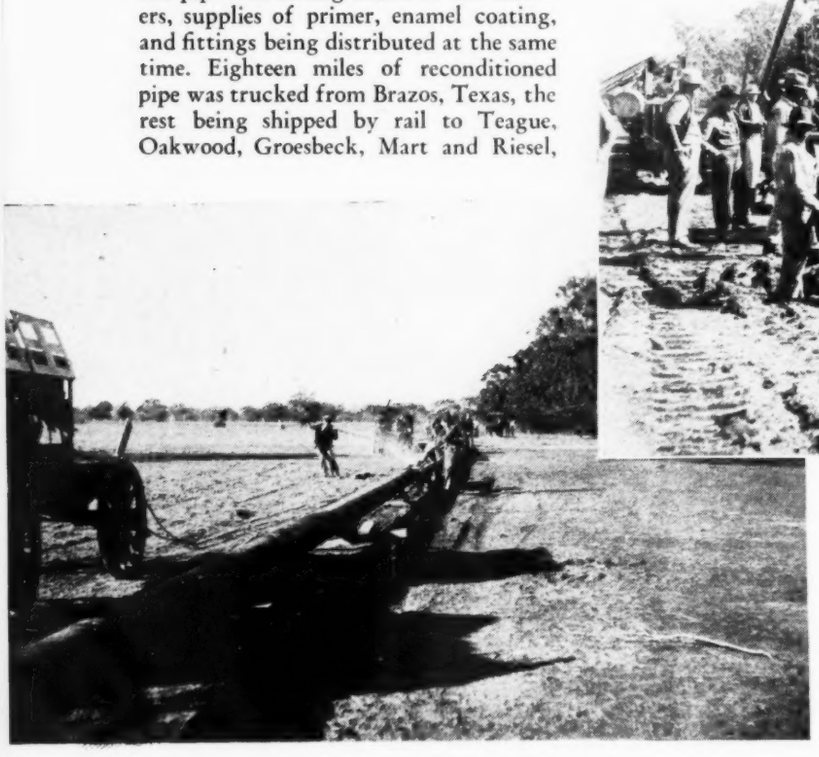
Latest construction methods and modern heavy-type equipment were employed for the entire project. All joints were roll-welded, and the complete line coated with hot enamel and wrapped with asbestos felt as a protection against corrosion.

Two crews were employed, one working from the east and the other from the west end of the line. Following the clearing and grading of the right-of-way the pipe was strung ahead of the ditchers, supplies of primer, enamel coating, and fittings being distributed at the same time. Eighteen miles of reconditioned pipe was trucked from Brazos, Texas, the rest being shipped by rail to Teague, Oakwood, Groesbeck, Mart and Riesel, from which convenient points it was transported to the line by truck. The longest haul was a 52-mile turn around. Seventeen trucks and trailers were used for hauling. Two trucks equipped with cranes were employed to unload the pipe from freight car to truck. The reconditioned pipe was of varying lengths, averaging approximately 20 feet. The new pipe came in 40-ft. lengths. An average of five joints of new pipe was carried by each truck, and from 10 to 12 joints of reconditioned, depending upon the length. State law limits a truck's load to 7000 pounds. Upon arrival at the place for unloading, the pipe was snubbed off the trucks, over the side, old automobile tires being placed on the ground to break the fall.

Equipment used by each firing line gang consisted of a line-up tractor and seven 300-amp. electric welding machines, one for tacking and six for roll-welding. Twenty-five roll-welded sections were averaged to the mile. Each welding gang had an extra welder for making early morning tie-ins, setting gate valves, making general repairs, etc. The number of joints to a section was not uniform due to the irregularity of the ground and the varying lengths of the pipe. Tractors were employed exclusively for lining up the pipe on skids and dollies.

An interesting piece of equipment devised by Mr. Day, was used in connection with the torch-cutting of the pipe ends prior to welding to assure a smooth and true edge. Since second-hand pipe was used mostly on the job there were many uneven ends that had to be "trued" before a good job of welding was possible. The device used consists of a steel band that clamped around the pipe. It is provided with a hinge and a latch, and when in place fits the pipe snugly so that the cutting torch, played along its outer edge, performs a smooth job and results in a perfectly square joint. The "cutting-jig," as it is designated, weighs but 16 or 17 lb. and is easy to handle. An interesting sidelight on this cutting procedure was the fact that "Stargas," a product of the Lone Star Gas Company, was used as a fuel for the cutting torch.

All welds were tested. After closing the ends of the sections of pipe (approximately a mile in length) by means of

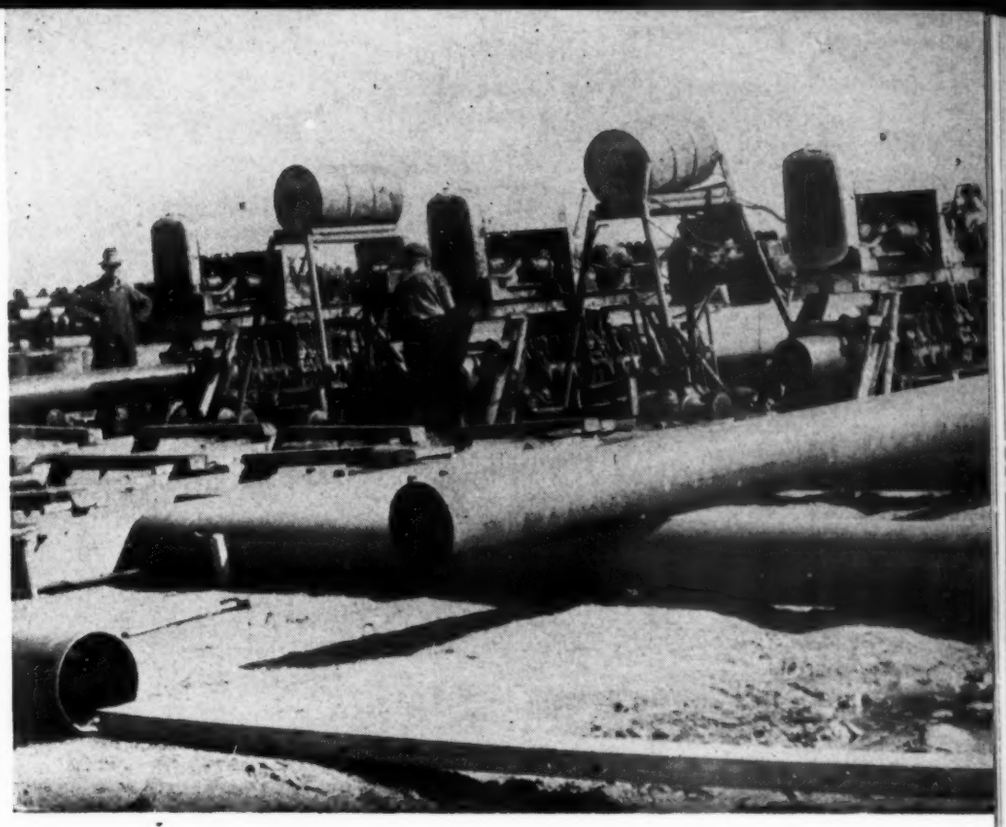


Above—Wrapping the pipe with asbestos felt, using a "paper wheel"

Left—The "firing line." The pipe was roll-welded into sections of approximately a mile in length, the tie-ins being made with bell-hole welds

Texas Line

By
FRANK H. LOVE



Stationary cleaning machines were employed for reconditioning salvaged pipe before shipping to new destination

bull plugs, air pressure of 50 to 60 lb. was put on the line and the welds given an application of soapsuds. Few faulty welds were found.

Due to the caving nature of the soil, tie-ins were made ahead of the ditchers in order that the pipe might be put in the ground immediately after the trench was dug and before a possible heavy rain. Bell-hole welds were used in making the tie-ins. Two 30-hp. Caterpillar tractors were employed to "butt up" the sections and three tie-in welders were worked in each crew, as well as one extra welder, to make early morning tie-ins. A tie-in was made approximately every mile.

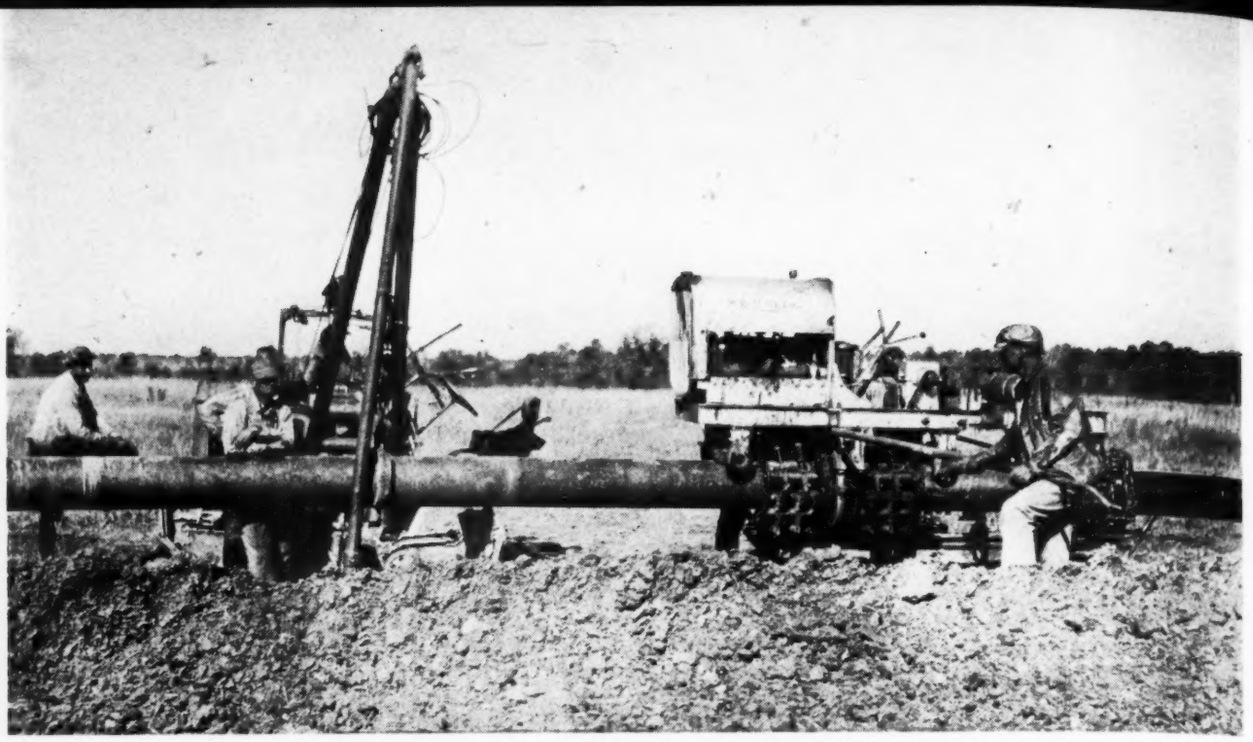
Several hundred overbends and sags were required over the length of the line and these were all made cold. For this work two tractors equipped with booms and winches were used. No special crew was employed to make the bends, the tie-in gangs taking care of that along with their other work. The tractors were used quite effectively. When a sag was needed one tractor was run up on the center of the pipe, holding it rigidly against the ground. The operator of the other tractor hooked on to the end of the pipe with a winch line and a steady upward pull was exerted until the pipe was bent slightly farther than required so as to allow for a spring back when the tension was released. In making an overbend a chain was looped around the center of the pipe and secured to one of the tractors. The other tractor fastened on to the ends of the pipe by means of a winch line and pulled it into the required shape, the first tractor holding the pipe steady.

After the pipe had been strung, welded into sections, and tied in, the heavy-type ditchers were put to work, digging a trench 24 in. in width and 34 in. in depth. Two ditchers were used on either end of the line. For the most part ditching was easy. The country traversed was of a rolling nature and the soil soft, except for a short stretch in Freestone County where some 1000 ft. of rocky formation was encountered. Some powder blasting was required here. The Trinity and Navasota rivers were crossed, as well as Keechi Creek and numerous small branches. Each ditcher averaged approximately 3500 ft. daily, while the best record made by a single machine in a 24-hour day was 6500 feet. All highway and railway crossings were bored, an augur-type boring machine being used. Sixteen-in. steel casing was set in the tunnel thus bored and the 12-in. pipe pulled through. Before setting the casing it was first cleaned, primed and coated.

Prior to applying a hot enamel coating the pipe was given a final cleaning and coat of primer. A late model cleaning machine with a priming head attached was employed and the processes were accomplished in one operation. The machine was of the traveling type that moves along the top of the pipe. As it progresses the supporting skids are removed from beneath the pipe to allow it to pass, a tractor equipped with winch and boom holding the pipe suspended. After the machine passes the skids are replaced. The machine is equipped with steel cutter wheels and large steel brushes that rotate around the pipe, thoroughly removing rust and dirt. The primer is fed into a tank attached to the machine and flows through a small tube to the top surface of the pipe. As the primer flows down the sides of the pipe rotating brushes spread it smoothly over the entire surface.

In applying the hot enamel coating a departure was made from ordinary procedure. The enamel was poured over the top of the pipe and ragged on in the usual manner, but 10 to 15 feet behind this crew came another applying a second coating to the underside of the pipe. This second coating covered approximately a third of the pipe's surface and served to eliminate "icicles" and "holidays," as well as to impart a smoother finish to the coating. A 60-hp. Caterpillar tractor carried the pipe in a sling, three rollers being attached to the winch line. Upon these rollers the pipe rested, making it possible for the tractor to move smoothly along the line ahead of the "doping" gang without the priming coat being scratched.

Holiday detectors, instruments of comparatively recent origin, located pin holes or breaks in the enamel coating. The detector consists of a metal ring from which extends numerous fine wire fingers. The ring encircles the pipe, the fine wires touching its surface. The apparatus is moved along the pipe by hand and when any of the wire fingers come in contact with a thin spot in the coating or make contact with the pipe at a place where there is a break in the enamel an electric current supplied by a storage battery closes the circuit and the short thus created causes a buzzing sound. Each break is marked with chalk, and a crew of daubers follows closely behind to apply more enamel to these breaks and weak spots. After these daubers comes another holiday detector and behind it a second crew of daubers. Before the coating is pronounced satisfactory the holiday detector is passed over the line a third time, followed by a third daubing



Traveling-type cleaning machine with priming head attached

crew, assuring a thorough coating job. The enamel coating was put on the pipe to a thickness of 1/16 to 3/32 of an inch.

The final operation before lowering the line into the ditch was wrapping the pipe with asbestos felt applied as a spiral wrapping by means of a "paper wheel," with which two men can wrap approximately two miles of pipe per working day.

After the wrapping was completed the pipe was looped in and out of the ditch, a slack loop being left to every 400 to 500 ft. on level ground and at varying distances where the topography of the country was irregular. The purpose of these slack loops, of course, was to provide for contraction and expansion. The slack loops were left resting on skids while the backfillers covered the pipe in the ditch. Slack loops were all lowered into the ditch at approximately 4 a. m. in order that the pipe would be fully contracted. The second backfilling crew followed this gang and completed the backfill. The lowering work was accomplished entirely with the use of tractors equipped with winches and booms. A sling or cradle was used rather than hooks to prevent damage to wrapping and coating.

Gate valves were located every six to eight miles, and set in concrete boxes. Twenty feet on either side of the valve a concrete block ten ft. long and four ft. wide was placed sidewise across the ditch. The blocks varied in height, in loose soil being five ft., in other soils four feet. A sleeve coupling was installed on either side of the valve.

Some difficulty was encountered in crossing the Trinity River. The trench across this stream, which is approximately 100 ft. in width at the point of crossing, was blasted. Three-in. steel tubes were sharpened on the end and driven 32 in. below the bed of the river. These were spaced every five ft. and in each was placed a charge of nitroglycerine, 750 lb. of which was used to blast the trench. The tubes were joined by a wire that extended 400 to 500 ft. from the river bank to a battery, and when all was in readiness the charges of nitro discharged simultaneously. To the end of the line pipe, which previously had been "doped," wrapped and welded, a bull plug was welded on and the pipe pulled into the trench by a tractor. Fifteen river clamp sleeves were used to weigh the pipe down, and to prevent leakage in case of a break in a weld under the river.

Crossing the Navasota River was a simple process, as the water was at a low level. The trench was hand-ditched and the pipe laid in much the same manner as the remainder of the line. No river clamps were required.

The bulk of the reconditioning work was performed at the points in Texas and southern Oklahoma where the pipe was taken up. The pipe was lifted, a ditcher first running over the line stripping it. Following the ditcher came four tractors equipped with side booms. Hooking on to the pipe it was lifted from the trench. The procedure followed was for three tractors to be lifting at all times while the rearmost one unhooked and returned to the front of the line. As the pipe was lifted above the trench skids were placed under it. The salvaged pipe being part of coupled lines, the next step was to torch-cut the bolts. A truck equipped with a winch followed the cutters and jerked the joints of pipe from the couplings after the bolts had been removed. The joints were left alongside the ditch and were later picked up by trucks and hauled to concentration points, where three cleaning machines were in operation. These machines were of the stationary type. As the joints of pipe were run through they were cleaned by rotating steel cutter wheels and brushes. The machines can be operated at four speeds, ranging from a compound low, requiring six minutes for a 20-ft. joint to pass through, to a high speed requiring but one minute. The pipe was run through the machines at a speed varying with the condition of the pipe. Some joints had to be put through several times. After the pipe had been cleaned by the machines the bad portions were spot-welded and patched, four electric-welding machines being used for this purpose. Approximately one-third of the old pipe used in construction of the line came from Texas and two-thirds from southern Oklahoma, and had been in the ground from 5 to 17 years.

No additional compressor stations are needed to operate the line just completed, since closed-in rock pressure on the wells supplying the gas is 2250 lb., sufficient to boost the gas under pressure to the junction near Waco. The wells are all equipped with bottom-hole chokes to control the delivery of gas without freezing. The gas will go into the line at a pressure of approximately 350 pounds. Five wells comprise the Long Lake field proper, although the Hunt Production Company recently brought in a gasser two and a half miles northeast that is considered an extension to the field. The five wells serving the Lone Star line are producing from an average depth of 5043 feet. Two are producing gas and oil, the others gas only.

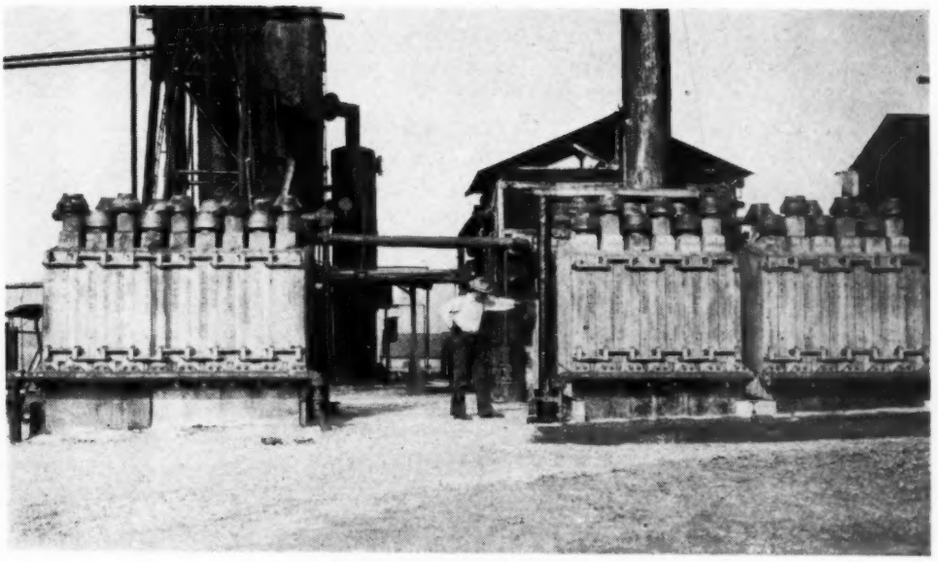


Fig. 1. National Oil-Rator treating plant at Waterloo, Arkansas, refinery of Berry Asphalt Company

By
J. W. SMITH
Superintendent, Berry Asphalt Company, Waterloo, Arkansas

Emulsions Treated At Low Cost

IN December, 1933, the Berry Asphalt Company installed at its Waterloo, Arkansas, refinery three large "high capacity" type National Oil-Rators to treat emulsion. Fig. 1 is a photograph of the Oil-Rator part of this treating plant in which a combination of heat and chemical is used. The heat is applied in the three cast-iron sectional gas-fired units, which were purchased from National Radiator Corporation, Johnstown, Pennsylvania.

A flow diagram of the installation is shown in Fig. 2. Raw oil is taken from storage (1), by steam pump (2), which is governed by flow control A. Chemical is added at C, oil passes through heat exchanger (3) and is heated to 210-220 deg. fahr. in the 10-section Oil-Rator unit (4). Sixty per cent or more of the water separates out in the gun barrels (5) and (6), and is removed from the system. Oil is then moved by steam pump (7) through two parallel-connected 7-section Oil-Rators that comprise the heater unit (8), where it is heated to about 240 deg. fahrenheit. The remaining water flashes off as steam in the water vapor tank or evaporator (9). From this tank a pump (10) drives the treated oil back through the heat exchanger (3) and to the storage tank (11).

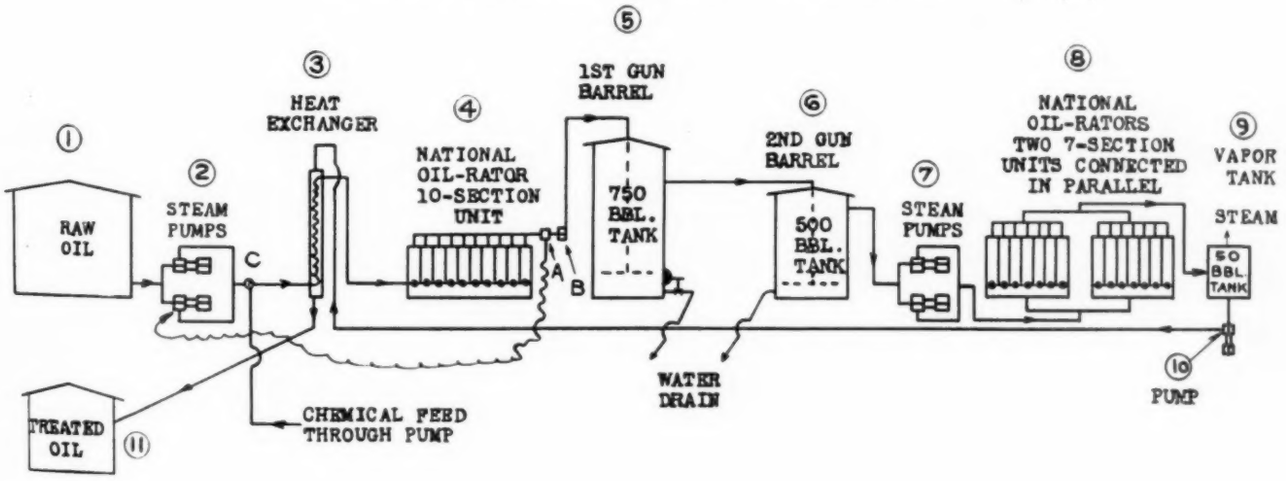
Although gas is used for fuel, the units are set so that they can be converted easily to oil-firing if a change in the relative price of the fuels should warrant. The 10-section heater is kept as full of water as possible, so that the incoming emulsion is forced to percolate up through this hot water. Pressure in this unit averages 20 lb. per sq. in., and in the 7-section units about 12 lb., leaving a wide margin under the 60 lb. per sq. in. pressure rating of the sections, which are tested at the factory in accordance with A.S.M.E. requirements.

Operating Data

Following are representative operating data that clearly demonstrate the effectiveness of this means of treating.

The crude oil treated averages 14 deg. A.P.I.; flash-point, 330 deg. fahr.; initial boiling point, 500 deg. fahr.; and contains about 60 per cent 100-penetration asphalt. Water content varying from 15 to 45 per cent is reduced to between 0.4 and 1 per cent.

Fig. 2. Flow diagram of National Oil-Rator treating plant



First Heater

Temp. at entrance—80 deg. fahr. Temp. at outlet—205 deg. fahr.	125 deg. fahr. rise	(Temperature taken at 5-min. intervals with recording thermometer)

Second Heater

Temp. at entrance—194 deg. fahr. Temp. at outlet—245 deg. fahr.	51 deg. fahr. rise	(Temperature taken at 5-min. intervals with recording thermometer)

Sample raw oil through first heater—34 per cent water (3-min. intervals)
Sample raw oil through second heater—22 per cent water (3-min. intervals)
Sample of treated oil to storage—0.4 per cent water (3-min. intervals)

Average gas pressure at meter	32 lb. per sq. in.
Average heat value of gas	1000 B.t.u. per cu. ft.
Raw oil	2619 gal. per hr.
Treated oil	1572 gal. per hr.
Gas metered	3830 cu. ft. per hr.
Total heat absorbed, first heater	1,804,000 B.t.u. per hr.
Total heat absorbed, second heater	3,962,000 B.t.u. per hr.
Total heat absorbed, both heaters	5,766,000 B.t.u. per hr.

Total heat input, 11,820,000 B.t.u. per hr.

Thermal efficiency, 48 per cent.

At 10 cents per 1000 cu. ft., fuel cost, $0.019 per barrel.

On a recent run of about 1600 bbl. daily for two weeks, the chemical cost was 1.2 cents per bbl. and the fuel cost 1.1 cents per bbl., which is exceptionally low-cost treating for the type of emulsion that is being handled. No labor cost is charged against this equipment, because it requires so little attention that the stillman helper handles it along with his other duties. No repairs have been made to date, and the management estimates that this cost will remain very low. A recent inspection showed that, in spite of the corrosive nature of the crude oil and salt water mixture, there was only a light coat of rust in the section. This is characteristic of cast-iron, for rust as it forms adheres tightly, and protects indefinitely the metal underneath against further corrosion.

Fig. 3. An Oil-Rator installation in the East Texas field

Investment Cost Low

The actual cost of this new type plant was $5140 installed, of which approximately $4100 was for the Oil-Rators and $1040 was the cost of special controls, accessories and piping, and the labor required for installation. The gun barrels, evaporator, storage tanks, etc., were already available and, consequently, are not included in either of the cost figures.

Oil-Rator units were chosen by the Berry Asphalt Company because its engineers felt that the higher investment in any other type unit would not be balanced by a lower operating cost, and because the high velocity of flow required by the method prevailing in that vicinity tends to re-emulsify the oil and water, while the very low velocity in an Oil-Rator unit aids separation.

Following a suggestion by Berry engineers, the design of the Oil-Rator has been modified to use external, bolted cast-iron headers, instead of the push nipple construction formerly used for the flow passages at top and bottom between sections.

The cost of installation at the Waterloo refinery should be materially lowered on a lease, because the setting for either gas- or oil-firing would not be needed, and the new bolted header construction permits quicker assembly with less skilled labor. Experience in making the installation at Waterloo and at other locations indicates that six men should be able to set up a 10-section unit in ten working hours. This means a rate of six man-hours per section.

East Texas Field Unit

Fig. 3 shows an installation of a 3-section high capacity type unit in the East Texas field, in conjunction with a 500-bbl. wooden settling tank. The crude entering the heater averages 87 per cent oil, 11 per cent water and 2 per cent emulsion. Some 150 bbl. of oil are recovered daily, the product showing about 0.6 per cent B.S. as it comes from the Oil-Rator. Oil from the stock tanks ranges from 0.2 to 0.5 per cent B.S. when run to the pipe line. A recent test on this plant for a 6-hour period showed 56.6 per cent thermal efficiency for the Oil-Rator, but shorter tests have given as high as 61.8 per cent efficiency. These moderate efficiencies, combined with their high capacity, make the "high capacity" type unit economical where fuel is cheap. Where fuel is relatively expensive the "high efficiency" type unit, developing about 80 per cent thermal efficiency at somewhat lower capacity, results in lower overall costs.

It will be seen from Figs. 1 and 3 that these units require no housing. Due to their sectional construction they can be taken apart easily for transportation and reassembled on a new location. This construction also permits adding or removing sections to adapt the capacity to changed requirements. Deposits of mud and sludge are removed through cleanout openings that make the entire interior accessible.

Summary

These units are proving effective and economical in treating crude oil emulsions. The Berry Asphalt Company has operated three large units over a period of almost a year, at its Waterloo, Arkansas, refinery, in conjunction with chemical treatment. Tests on this and other installations in actual service show thermal efficiencies ranging from 49 to 62 per cent. In the Waterloo refinery, crude containing from 15 to 45 per cent water and emulsion is reduced to well under one per cent B.S. content. Operating costs (fuel, chemicals, operating and maintenance labor), average about 2.3 cents per bbl. of treated oil, compared with costs of 8 to 12 cents per bbl. in a near-by plant. The total investment in this equipment, ready to operate, was less than one-half that estimated to build an acceptable design to perform the same work.

With its features of cleanability, corrosion-resistance, and flexibility, it is expected that with these sectional cast-iron heaters low treating costs will be maintained for many years.

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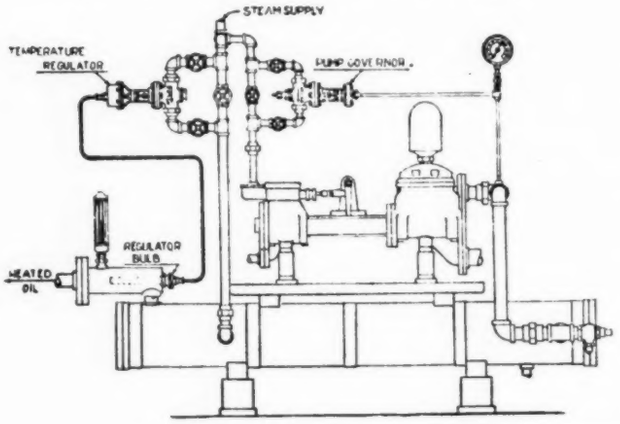
Controlling Temperature of Fuel Oil to Refinery Boilers

By W. F. SCHAPHORST

IF you are burning oil under your refinery boilers, you probably would like to know how the temperature of the fuel oil can be positively regulated and held at the desired point.

Herewith is a sketch that shows clearly how to do it. A temperature regulator bulb is placed in the fuel oil pipe close to the point of exit. This bulb, through its temperature regulator, causes steam to be turned off and on as required to maintain the desired temperature, the steam being bypassed through the temperature regulator as shown.



At the same time, a pump governor, shown directly over the steam pump, controls the pressure of the same fuel oil. In other words, temperature and pressure are both simultaneously controlled, using a common source of steam supply.

Continental Receives National Safety Awards

Two important awards for unusually safe operating conditions during the first six months of 1934 have been presented to Continental Oil Company, Ponca City, Oklahoma, by the National Safety Council, Joe S. Boylan, in charge of Continental's safety and sanitation division, has announced.

The most outstanding award, for winning first place, was made to Continental's production department, and was based upon the fact that only four lost time accidents were suffered among 1439 men during the half-year period. The second trophy went to Continental's natural gasoline division, which has had a perfect safety record for four consecutive years.

Presentations were made during the National Safety Council's 23rd annual congress in Cleveland. Both awards were in the form of large bronze placques.

During the annual meeting of the American Petroleum Institute in Dallas, Continental's production department also received a certificate for winning first place in the A.P.I.'s 1933 production contest.

Lone Star Gas Company Given Safety Awards

The Lone Star Gas Company of Dallas, Texas, was the recipient of two safety awards at the recent meeting of the National Safety Council in Cleveland, the trophies being beautiful plaques. The pipe line and compressor departments of the Lone Star won first place in Group A of the pipe line division for having a record of 735,869 man-hours worked with only one disabling injury, giving them a frequency rate of 1.359. The natural gasoline department was given first award in Group B, with a record of 66,801 man-hours exposure without a disabling injury. The contest covered a period of six months. A. W. Breeland, safety supervisor for the Lone Star Gas Company, is shown in the above photograph holding the two trophies.

During the recent meeting of the American Petroleum Institute in Dallas the natural gasoline department of the Lone Star also was given an accident prevention award by that body, covering the year of 1933, for working the entire year with an accident frequency rate of only 2.30 injuries per one million hours worked.

Refinery Economics

Article 3. Economics of Unit Refining Operations

By W. L. NELSON
Consultant*

THE true economy of a process can only be ascertained by a detailed study of the items of equipment that compose the plant. There are so many units that only a few of them can be discussed. Among the units that can be conveniently studied are: (1) Pumps; (2) Exchangers; (3) Pipestills; (4) Boilers; (5) Insulation and Piping; (6) Refrigeration Equipment; (7) Compressors; (8) Fractionating Towers; (9) Absorbers and Strippers; (10) Treating Equipment; (11) Dewaxing Equipment, etc., etc. There is hardly an end to the phases of economic study that can be followed.

In general the method of approach is to determine the factors that are vital to the cost and then balance these factors against one another. In any equipment the operation can be varied within limits and there will be an optimum manner of operation by which the cost of operation is a minimum or the saving is a maximum. The cost items that govern the optimum manner of operation may be classified as follows:

1. Investment charges, such as cost of equipment and interest on the investment.

2. Cost of materials, such as fuel, chemicals, steam, etc.

3. Cost of supervision, labor and overhead. With rare exceptions this item of cost is nearly constant in a particular refining operation and may be neglected in determining an economic balance.

4. Cost of repairs. In some instances this cost is dependent on the manner of operation, but in others it remains nearly constant and can be neglected as far as the economic balance is concerned.

The most economical approach between the temperature of the flue gas that leaves a pipestill and the temperature of the incoming charge stock, is a good example of the relation between the aforementioned factors. As the difference between these temperatures increases the flue gas enters the stack at a higher temperature and the cost for fuel oil rises. The only way to decrease the approach is to build more convection section in the pipestill and hence the investment charge increases. The total of the two costs, investment and fuel, governs the economic balance and the total cost reaches a minimum at a temperature difference of about 300 deg. fahrenheit.

*Professor of Petroleum Refining, University of Tulsa.

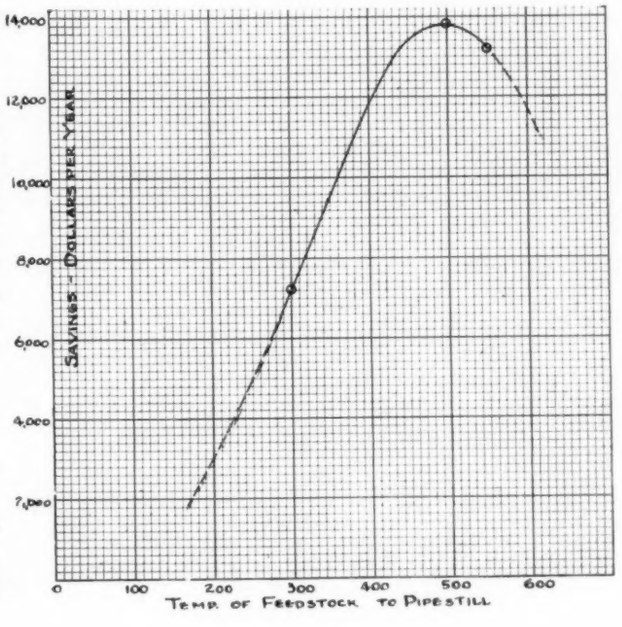


Fig. 1. Savings by the use of heat exchange on a 20,000,000-B.t.u. pipestill

Another example is the most economical thickness of insulation for pipe lines. The cost of the insulation increases as the thickness is increased. The heat that is saved is also dependent on the thickness, but it is also dependent on the outside area of the insulation because an air film that is an effective insulator is present at the surface. The heat that is lost is dependent not only on the resistance of the insulator but also on the square feet of surface that is exposed. Hence, for small pipe sizes more heat is lost if the pipe is insulated than if it is bare.

Heat Exchangers

The saving that is accomplished by the recovery of waste heat approaches a maximum at a particular set of conditions, for any heat exchange equipment. The value of the heat that is saved less the cost of the investment and the cost of operating and maintaining the equipment is defined as the net saving. At some set of operating conditions the net saving is a maximum and if the conditions are changed, either the equipment cost or the cost of heat rises abnormally and lowers the net saving.

In selecting heat exchangers an important consideration is the most economical approach, or difference in temperature between the outgoing and incoming mediums. The maximum amount of heat is recovered when there is no temperature difference or the approach is zero, but an infinite amount of surface is required to recover this much heat.

The net saving may be conveniently handled by a mathematical expression. Such an expression can be derived as follows:

Dollars per year when saving one million B.t.u./hr. = Value of heat — Depreciation — Upkeep.

S = Savings in dollars per year when saving 1,000,000 B.t.u. per hour.

Cf = Value of heat in dollars per million B.t.u.

Cs = Cost of equipment in dollars per sq. ft. of surface.

Cr = Cost of repairs and cleaning.

Y = Years to depreciate the investment.

I = Interest rate (divided by 100).

H = Transfer rate.

d = Logarithmic mean temperature difference.

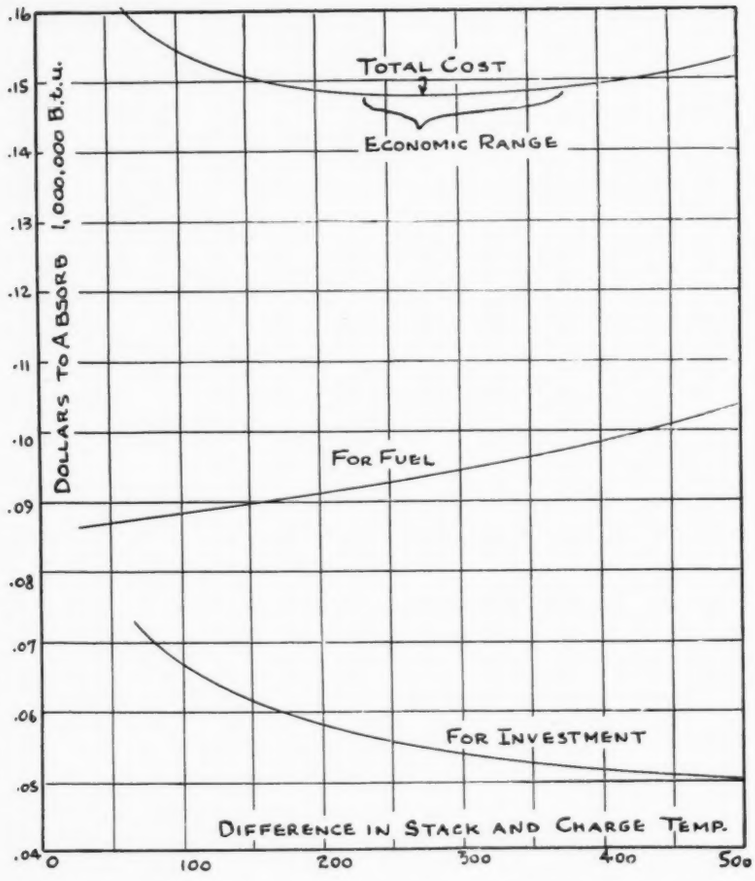


Fig. 2. Cost of heat versus pipestill approach

Below is given saving, heat, depreciation and upkeep:

$$S = 320 \times 24\,Cf - \left[\frac{1{,}000{,}000\,Cs}{d\,H} + \left(\frac{1{,}000{,}000\,Cs}{d\,H}\right)\left(\frac{I+C}{2}\right)Y\right]\frac{1}{Y} - Ce$$

$$S = 7700\,Cf - \left(\frac{1{,}000{,}000\,Cs}{d\,H}\right)\left(1 + \frac{I\,Y}{2}\right)\frac{1}{Y} - Ce$$

$$S = 7700\,Cf - \frac{500{,}000\,Cs}{d\,H\,Y}\left(2 + I\,Y\right) - Ce$$

This equation appears to be complex, but it becomes simple if the known variables are set into it. As an example, if the value of heat is 15 cents per million B.t.u., the cost of surface is $3.00 per sq. ft., the interest rate is six per cent, the transfer rate is 50 and the equipment is to be depreciated in six years, the equation takes this simple form:

$$S = 1158 - \frac{11{,}800}{d} - Ce$$

This equation will be used to compute the most economical approach for an exchanger for cooling one part of material at 500 deg. fahr. with two parts of material at 300 deg. fahrenheit. The exchanger absorbs one million B.t.u. per hr. when the approach is 100 deg. fahrenheit. At other approaches the saving per year is as follows:

Approach deg. fahr.	Saving per million B.t.u.	B.t.u. saved per hour	Total saving dollars per year
100	1062	1,000,000	1062
50	1014	1,500,000	1520
30	971	1,700,000	1650
20	931	1,800,000	1670
10	866	1,900,000	1640

Thus, it is most economical to use an approach of 20 deg. fahrenheit.

The cost of upkeep was neglected entirely because it will be about constant regardless of other conditions and does not affect the most economical approach.

The results of similar computations for other conditions are shown in Table I. The conditions are the same as in the example except for those that are given in the table.

The data in Table 1 show clearly the effect of the several variables on the most economical approach. A summary of the effect of these variables follows:

(1) A high surface cost increases the economic approach. (No. 1 and 2, Table I).

(2) A low transfer rate increases the economic approach. (No. 1 and 3).

(3) A large temperature difference at hot end decreases the approach. (No. 4 and 5).

(4) Rapid depreciation increases the approach. (No. 5 and 6).

(5) A high fuel cost allows a close approach.

Exchanger Used With Pipestill

Common practice is to use exchangers to heat the charge stock for a pipestill. However, as the charge stock arrives at

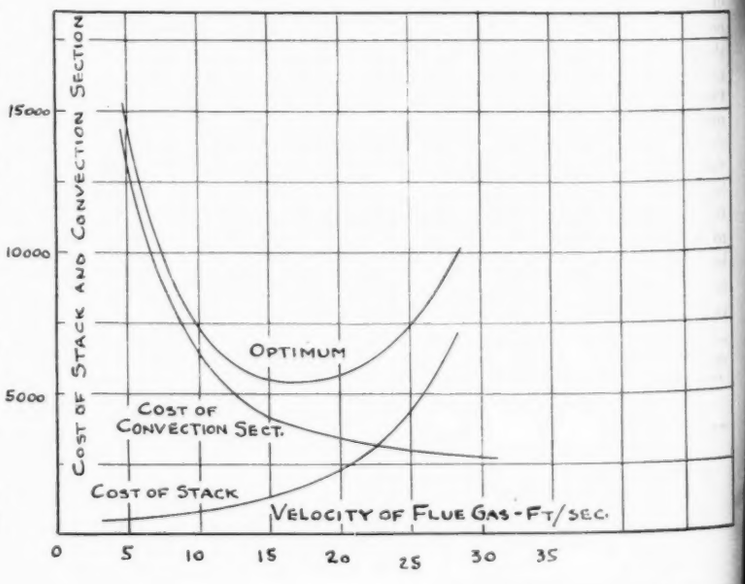


Fig. 3. Optimum flue gas velocity in convection section of pipestill

KOBE
HYDRAULIC DEEP WELL PUMP

The Kobe Hydraulic Deep Well Pump is a complete fluid operated pumping unit consisting of all the necessary equipment required to produce oil from wells of any depth under widely varying conditions.

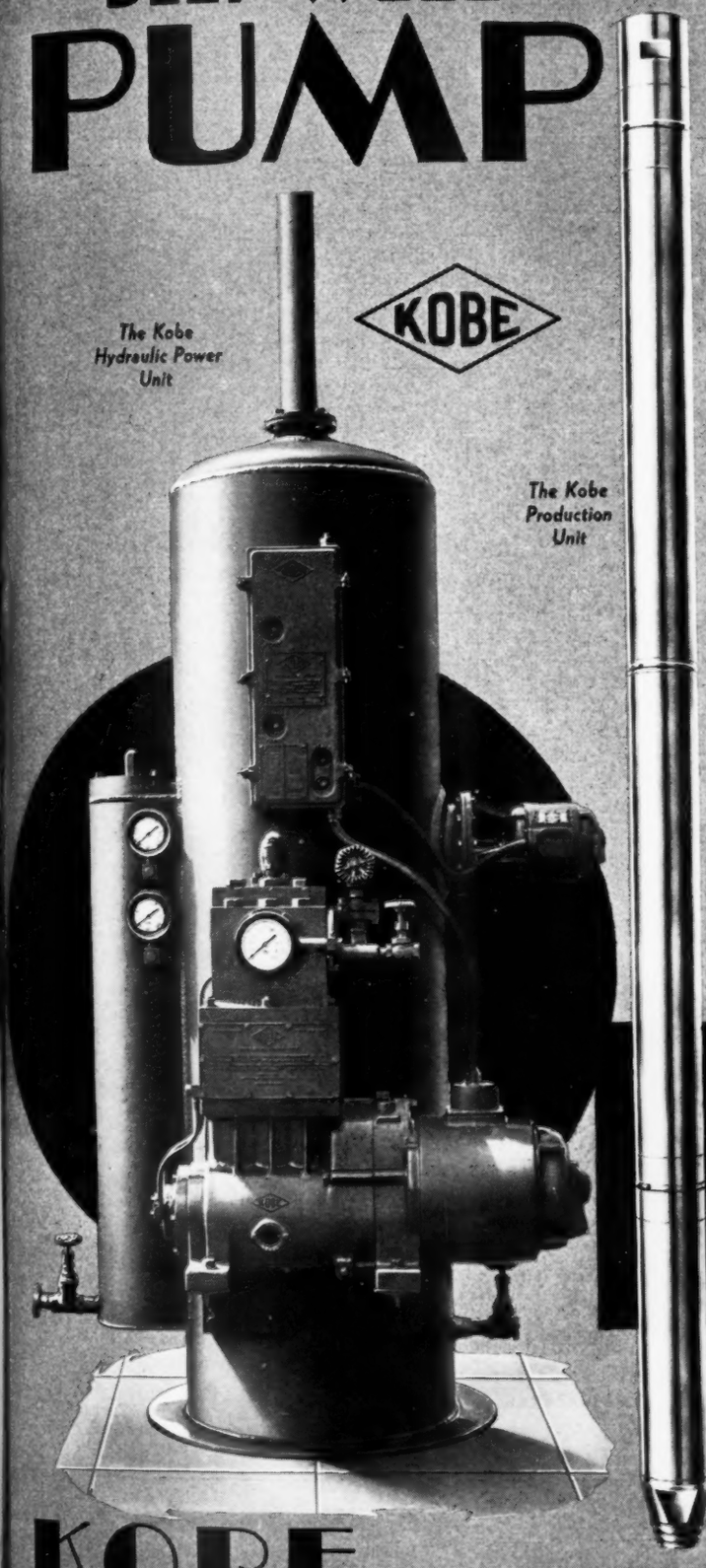
It embodies two main subdivisions: the surface, or Hydraulic Power Unit; and the subsurface, or Production Unit.

The Hydraulic Power Unit consists of a motor, triplex pump, operating switch, and filter, completely enclosed and self-contained, which may be located on the derrick floor or at any convenient point nearby. It is completely weather and dust proof, requiring no additional housing or special foundation.

The Production Unit consists of an engine and a production pump, combined into a single unit. The well tubing is set as a permanent string, with a shoe and gas anchor at the bottom; the Production Unit being attached to the lower end of the pressure tubing and seating in this shoe.

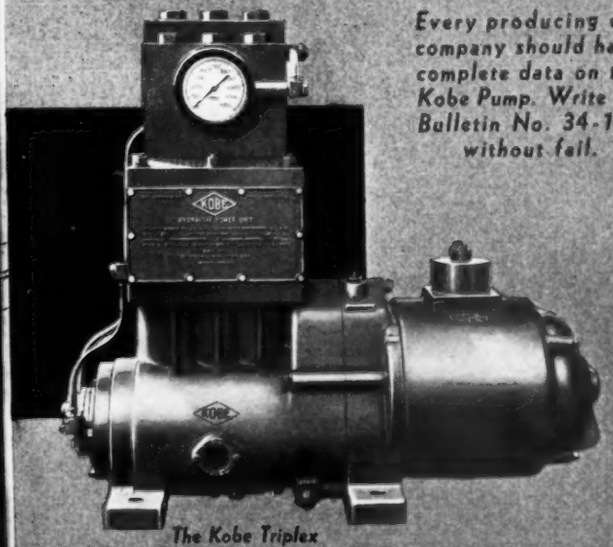
A Kobe installation includes complete pumping equipment with the single exception of tubing; all auxiliaries such as gas anchor, tubing head, control valves, et cetera, being supplied so that there is but one responsibility for its installation and operation.

It is adapted to individual well installations, or for producing a group of wells from a central power unit; developing overall efficiencies of from 50% to 75%; and reducing power, maintenance, and general operating costs to new, all-time lows.



The Kobe Hydraulic Power Unit

The Kobe Production Unit



The Kobe Triplex Pump

Every producing oil company should have complete data on the Kobe Pump. Write for Bulletin No. 34-100 without fail.

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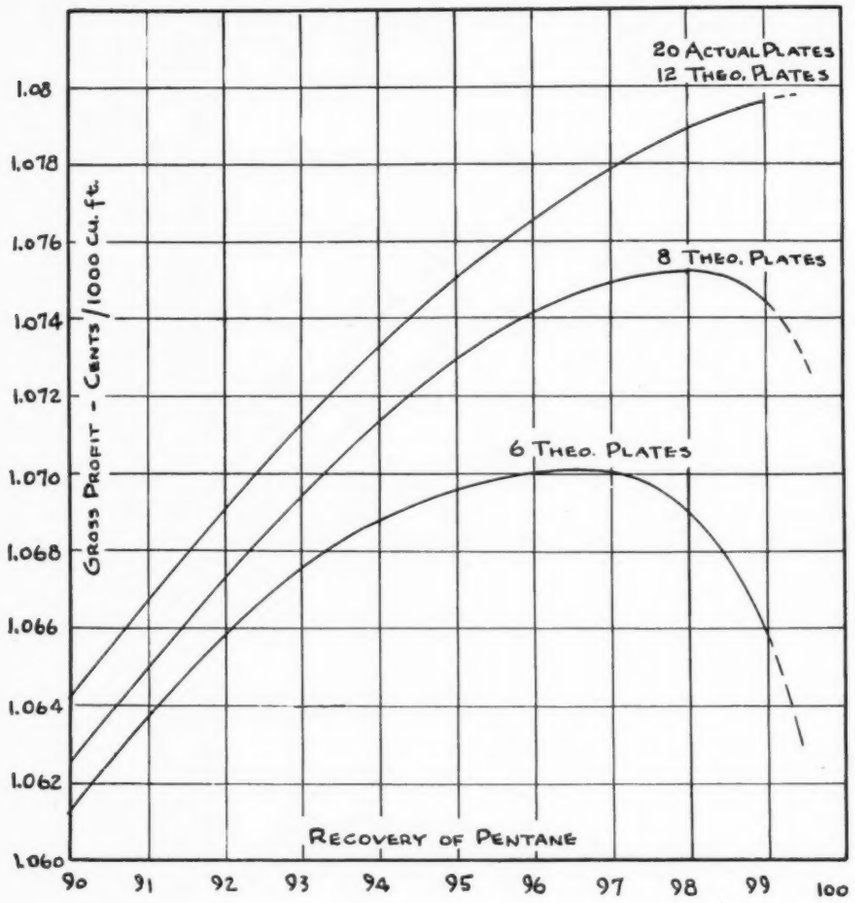


Fig. 4. Most economical recovery of pentane in a natural gasoline absorber

the pipestill at a higher temperature the efficiency of the still is decreased.[1] Less heat must be absorbed in the still but the temperature of the gases to the stack, and this temperature governs the efficiency, is higher. Furthermore, less cooling water and cooling surface is required in the condensers and coolers because the products are partly cooled by the exchangers.

To get a true picture of the economy of installing heat exchangers, all these factors must be considered, but to consider all these factors is too complicated for a paper of this kind. The approximate comparison of the costs of generating heat that appears below will serve to illustrate the relation of heat exchange to pipestill heating. Approximate costs of generating heat, not including daily labor costs and repairs, for a 20,000,000-B.t.u. topping still are as follows:

	Cents per Million B.t.u.	Saving, Dollars per year
Pipestill without exchangers	23	
With exchange to 300 deg. fahr.	17.3	7,220
With exchange to 500 deg. fahr.	14	13,820
With exchange to 550 deg. fahr.	14.3	13,200

[1]This is true unless more convection section is built in the still and to add more convection section obviously raises the cost of the still.

These data are shown in Fig. 1.

Pipestills

It is not economical to build a pipestill for the high efficiencies that are obtained in boilers. The reason for a lower efficiency is the high temperature of the charge stock. Oil is usually available at 300 to 500 deg. fahr., but feed water for a boiler may enter the economizer at 60 deg. fahrenheit. Thus, a boiler may operate at an efficiency of 80-85 per cent, but a pipestill operates most economically at 70-75 per cent. However, the efficiency of a boiler is usually computed for the boiler and economizer combined and this would be equivalent to computing the efficiency of the pipestill and exchangers combined. Hence, the actual difference in economy is not so great as it would seem at first glance.

The approach between the flue gas and the incoming oil is an important consideration. The flue gases should leave the pipestill at a temperature that is about 300 deg. fahr. higher than the temperature of the charge stock. A closer approach requires a much larger convection section and a larger approach allows so much heat to enter the stack that the cost of heating again rises. These relations are illustrated in Fig. 2. The figure was computed for a radiant type heater, absorbing 10,000,000 B.t.u. per hour; fuel cost 40 cents per bbl. and depreciation in six years.

Although a saving of one-half cent per million B.t.u. does not appear to be large, it amounts to about 3.5 per cent of the cost of generating heat and for a 20,000,000-B.t.u. still amounts to $1,500.00 per year.

Another interesting consideration is the optimum velocity for flue gas in the convection section. As the velocity is increased less surface is required in the convection section and the still is cheaper. But at the same time the friction loss increases and either a taller, more expensive stack must be used or a forced circulation system must be installed. The economic balance between these two costs, the cost of the stack and the cost of the convection section is shown in Fig. 3. Note that the cost rises greatly if the velocity range of 15-20 ft. per sec. is exceeded or not attained.

Natural Gasoline Plants

Gasoline plants are often designed for the recovery of 99 per cent of the pentane and heavier constituents of a gas.

TABLE I

Optimum Approach for Exchangers

Exegr. No.	Temp. deg. fahr. Hot Fluid	Temp. deg. fahr. Cold Fluid	Quan. by Wt. Hot Fluid	Quan. by Wt. Cold Fluid	Others	Optimum Approach deg. fahr.
1	500	300	1	2	none	20
2	500	300	1	2	C_s=$6	35
3	500	300	1	2	H=25	35
4	800	100	1	4	none	10
5	800	400	1	4	none	13
6	800	400	1	4	Y=2	15
7	800	400	1	4	Y=2 ; C_s=$6	25

TABLE II

Approximate Value of Gasoline by Operating Plant at a High Capacity

Capacity Cu. ft. per day	Relative Quantity of Oil Circulation	Estimated Fff. as No. Theo. Plates	Pctg. Recovery of Pentane+	Value Gasoline Dollars per Day
50,000,000	1	8	98	635
60,000,000	1	7	93	755
70,000,000	1	6	85.5	866
80,000,000	0.8	7	71	965*

*Might not operate successfully because of flooding column.

Under highly profitable conditions, such as a high gasoline price, a relatively rich gas or a gas that cannot be marketed, the recovery of 99 per cent may be justified. Usually a smaller recovery is more profitable. Fig. 4 was computed to illustrate these factors. The basis for the computations is:

50,000,000 cu. ft. of gas per day produce a 12 Reid V. P. finished gasoline.

$$\text{Yield} = 0.254 + 0.065 \times \text{Recovery}.$$

Analysis of Gas:

CH_4	83.8	iC_4H_{10}	0.7
C_2H_6	6.3	C_4H_{10}	0.8
C_3H_8	7.7	C_5H_{12}	0.2
		$C_6H_{14}+$	0.5

Fixed investment and labor charges 0.17 cents per thousand cu. feet. Cost of processing absorption oil 0.004 cents per gallon. Gasoline price four cents per gallon.

Low-Pressure Absorber

Inspection of Fig. 4 indicates that a high percentage absorption of pentane is not justified unless the absorber contains more than 13 actual plates. At a higher gasoline price or with a richer gas, the recovery of 99 per cent is always justified.

Under the present market conditions, and these conditions will probably continue for the next few years, it is doubtful if it will pay to recover more than about 97 per cent of the gasoline components.

Another interesting problem arises for the plant that processes a gas that has practically no market value and is available in large quantities. This situation has arisen in many isolated fields. Table II was prepared by using the same gas and general conditions as used in computing Fig. 4.

Thus, more gasoline is recovered if low percentages of pentane are recovered but the capacity must be greatly increased. To operate at 70,000,000 cu. ft. would increase the yearly profit by over $65,000. The profit will not be so great if the gas is richer in pentane.

Portable Work Bench for Gasoline Plants

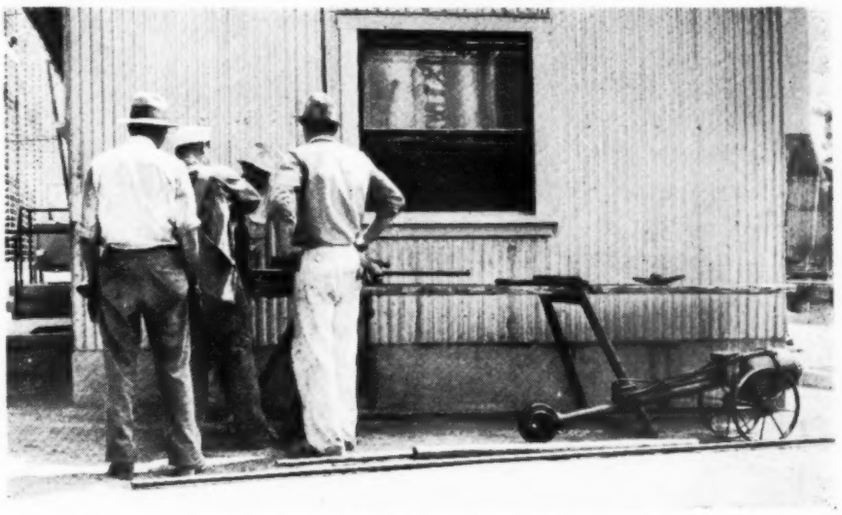
by

J. C. Albright

WORK benches used in gasoline plants upon which pipe vises are placed are usually heavy, cumbersome pieces of equipment more or less stationary, and when it is desired to work with them at a point some distance removed, the work is either brought to them, or they are transported with difficulty to the new location. Either procedure takes time. Some one with an inventive turn in the Gilmore-Dabney Gasoline Company's organization—a company that operates several gasoline manufacturing plants in the Signal Hill field of Southern California—had this very thing in mind when he designed a knock-down portable work bench for the workmen to use in various parts of the yard. If a little job, or for that matter one of consequence, is to be accomplished at a point across the plant yard from where the bench was last in use, two men can take it apart and move it to the new location and set it up again with practically no loss of time from their duties. It is not only easily transported, but being demountable, the bench may be stored in the tool or warehouse, occupying very little space.

When this work bench was constructed, salvaged materials were utilized both for the working surface and the supporting legs. Two-in. pipe was picked out of the scrap pile and cut in lengths so that when they were welded to form the legs, the height of the bench was at a convenient working level. As it was intended that 2 by 12 lumber was to be utilized for the working surface, the upper ends of each set of legs were welded to a cross piece just long enough to accommodate two pieces of the 2 by 12 planks intended for the working surface. Just below this top piece, another cross piece, slightly longer, was welded to the legs and spread the latter a trifle. The distance between the first and second cross piece was just a little wider than the thickness of the 2 by 12 planks, so that the legs would not bind when the planks were slid into the slot made by the two cross pieces. The opposite ends of the legs were tied together with another piece of 2-in. pipe, welded flush with the ends to form a base.

Two sets of legs were made, one for each end of the bench. When these were completed, the planks were slipped through the slots and the lower ends of the legs pushed towards the extreme ends away from the center. Various lengths of planks may be used, the lengths depending upon the requirements of the completed bench. For cramped spaces, short ones may be slipped in to make the bench, but if long pipe is to be threaded or cut, the longer pieces may be used. The bench is strong enough to hold any ordinary materials that may need working, and the heavier the weight placed upon it, the more solid it becomes. This type of work bench has been in use in the plants of this company for some time and has given the workmen a convenient tool upon which to place vises for pipe work and general repair. The cost is nominal, depending upon the accessibility of a welder and the nearness to the average scrap pipe.



Portable work bench described in this article

ANOTHER GREAT ADVANCE IN

OVER 500 miles of pipe line has been Lindewelded with the new Multi-Flame Lindewelding Head since the first of the year—and every mile is operating successfully today.

What It Is—And Does

Essentially, Multi-Flame Lindewelding involves three factors—the Multi-Flame Lindewelding Head; a special flame adjustment (employing a backhand technique exclusively); and a special welding rod. The Multi-Flame Lindewelding Head consists of a special chromium plated tip that has three flames: the main welding flame, and two auxiliary smaller flames located about 1¼ - in. from the end of the tip. These two smaller flames preheat both edges of the vee ahead of the point of welding. An excess acetylene flame carburizes the base metal surfaces just ahead of the advancing puddle. The special welding rod perfected for Multi-Flame Lindewelding insures the highest physical properties in the weld metal. The combination of these three factors has resulted in greater speed and economy in the production of pipe welds over previous methods.

Used By Men Who Know

Over one hundred experienced pipe line operators have already used the new Multi-Flame Lindewelding Head on hundreds of miles of pipe line. The strongest proof of their unqualified acceptance is found conclusively in the fact that the new Multi-Flame Lindewelding Head, which had its inception in the mid-continent field, has entirely superseded the single flame for all Lindewelding of pipe lines in that territory.

Proved Under Actual Conditions

In the heart of the mid-continent field, under the most adverse and grueling operating conditions, Multi-Flame Lindewelding literally went through a baptism of fire and emerged a perfected and accomplished technique. Here, this modern technique was tested, improved and rigidly retested with but one objective—to fill the industry's demand and need for more speed and economy in consistently producing good welds.

Saves Time, Rods and Gases

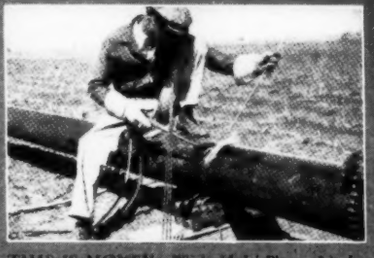
The enthusiastic acceptance of Multi-Flame Lindewelding by pipe line companies and contractors is due to its outstandingly greater speed, economy and ease of operation. It meets all field welding conditions, any size pipe, and wall thickness, jammed joints, excessive spacing, and high-low line-ups. Yet, important as these advantages are, the dominant fact is that with *the new Multi-Flame Lindewelding Head and the proper technique,* the average pipe line operator can effect *savings ranging from 15 to 40 per cent in welding time, rods and gases.*

Linde Process Service Cooperates

There need be no hesitancy in adopting Multi-Flame Lindewelding on your pipe lines. If you use Linde Oxygen, Linde Process Service Operators will help you organize your welding operations to secure the greater speed, efficiency and economy now possible with Multi-Flame Lindewelding. The development of Multi-Flame Lindewelding has conformed with the non-compromising standards set by Linde engineers since oxy-acetylene welding was first adopted for pipe lines. Standards that automatically require the work of development to be carried on in both the laboratory *and under actual operating conditions in the field.*

Lindewelding Performance Told in Pictures

RECORD RIVER CROSSING—With Multi-Flame Lindewelding this 8-in. line was laid across a river in one day—a notable record.

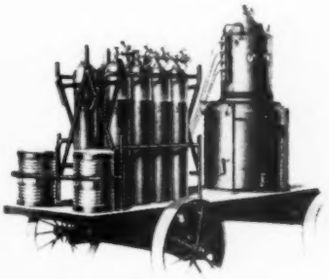


TIME IS MONEY—With Multi-Flame Lindewelding a saving of 25 per cent in welding time was made on this 10-in. pipe line.

89 WELDS PER MAN DAY—On a stretch of 6-in. line a record of 89 welds per man day was achieved by men with little previous experience with Multi-Flame Lindewelding.

FIFTY PER CENT INCREASE IN PRODUCTION was achieved on this 8-in. line. Six men averaged 304.6 welds per day with Multi-Flame Lindewelding.

You can order everything for Pipe Line Welding from Linde



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OXWELD APPARATUS AND SUPPLIES ... Oxweld offers the maximum value in oxy-acetylene equipment. Blowpipes, regulators, acetylene generators, welding rods, and supplies—are available for every welding and cutting operation. Complete stocks and service stations are located in all principal cities.

UNION CARBIDE ... sold in the familiar Blue and Grey drum from over 250 warehouse stocks.

PIPE LINE CONSTRUCTION

Contact the Nearest Sales Office

The nearest Linde Sales Office will be glad to furnish complete information on Multi-Flame Lindewelding and the cooperation extended by Linde Process Service. Offices are located at Atlanta — Baltimore, Birmingham, Boston, Buffalo, Butte—Chicago, Cleveland—Dallas, Denver, Detroit—El Paso—Houston—Indianapolis—Kansas City—Los Angeles—Memphis, Milwaukee, Minneapolis—New Orleans, New York—Philadelphia, Phoenix, Pittsburgh, Portland, Ore.—St. Louis, Salt Lake City, San Francisco, Seattle, Spokane and Tulsa.

Everything for oxy-acetylene welding and cutting—including Linde Oxygen, Prest-O-Lite Acetylene, Union Carbide and Oxweld Apparatus and Supplies—is available from Linde through producing plants and warehouse stocks in all industrial centers.

The Linde Air Products Company

Unit of Union Carbide and Carbon Corporation

In Canada: Dominion Oxygen Co., Ltd., Toronto

PERFORMANCE TELLS THE STORY

FIFTY Per Cent Increase in Production was possible with Multi-Flame Lindewelding on a line of 30 miles of 6-in. pipe with 5/16-in. wall, and 24 miles of 8-in. pipe with 1/4-in. wall. Multi-Flame Lindewelding was not available until after 14 miles of the 8-in. line had been welded. The remaining 10 miles of the 8-in. line was completed in three more days with Multi-Flame Lindewelding. This resulted in an average of 304.6 welds per day for six men which represented 50 per cent increase in production with no increase in personnel. Test welds were cut from the lines and given the reverse bend test. No welds failed in this test. This marked increase in production made the use of Multi-Flame Lindewelding on the longer 6-in. section a matter of course. The pipe was in 40-ft. lengths with 37½ deg. bevel. On this part of the line the six men averaged nine welds each per hr., or an average altogether of 4 miles per day in spite of sand and long moves. The line tested with 100-lb. air pressure proved absolutely tight.

Cross River in One Day. Another 8-in. line gives some further comparative data. The pipe lengths averaged 18 ft. and the weight of the pipe was 24 lb. per foot. The pipe in this case was from an old line and had been reclaimed by means of a pipe-cutting machine. Six welding operators were employed, four using the ordinary single flame blowpipe while two used the new Multi-Flame Lindewelding Head. The latter two attained a speed of 50 welds each per day, the former making but 40 welds each, or an increase of 25 per cent for Multi-Flame Lindewelding. One interesting section of this particular job was a 1500 ft. river crossing. By using special construction methods and Multi-Flame Lindewelding, the crossing was made in one day, a notable record.

Record of 89 Welds per Man Day. A prominent contractor of the mid-continent field has installed a number of lines with Multi-Flame Lindewelding. In one instance 30 miles of new 12-in. pipe were laid in 11 days. Considerable delay was experienced due to the nature of the country and river detours, so that several days were not worked full time. The six men on the firing line were averaging 30 or more welds a day even with these handicaps, and one day averaged 36.5. On a stretch of 8-in. pipe the same men averaged as high as 48 welds each per day, and on 6-in. pipe a record of 89 welds per man day was attained. Both 6-in. pipe and 8-in. pipe were 13/32-in. wall thickness, second-hand and beveled by a blowpipe cut. None of these welders had had much previous experience with Multi-Flame Lindewelding.

Saves 25 Per Cent in Welding Time. Still another contractor has been doing considerable work on 10-in. pipe of 13/32-in. wall thickness. On a 42-mile line laying new pipe in 40-ft. sections an average of approximately 38 welds per man day was obtained. There were four men on the firing line, each working on a string of five 40-ft. sections. The record made on this line with Multi-Flame Lindewelding represented a saving of 25 per cent in welding time over the older single flame tip.

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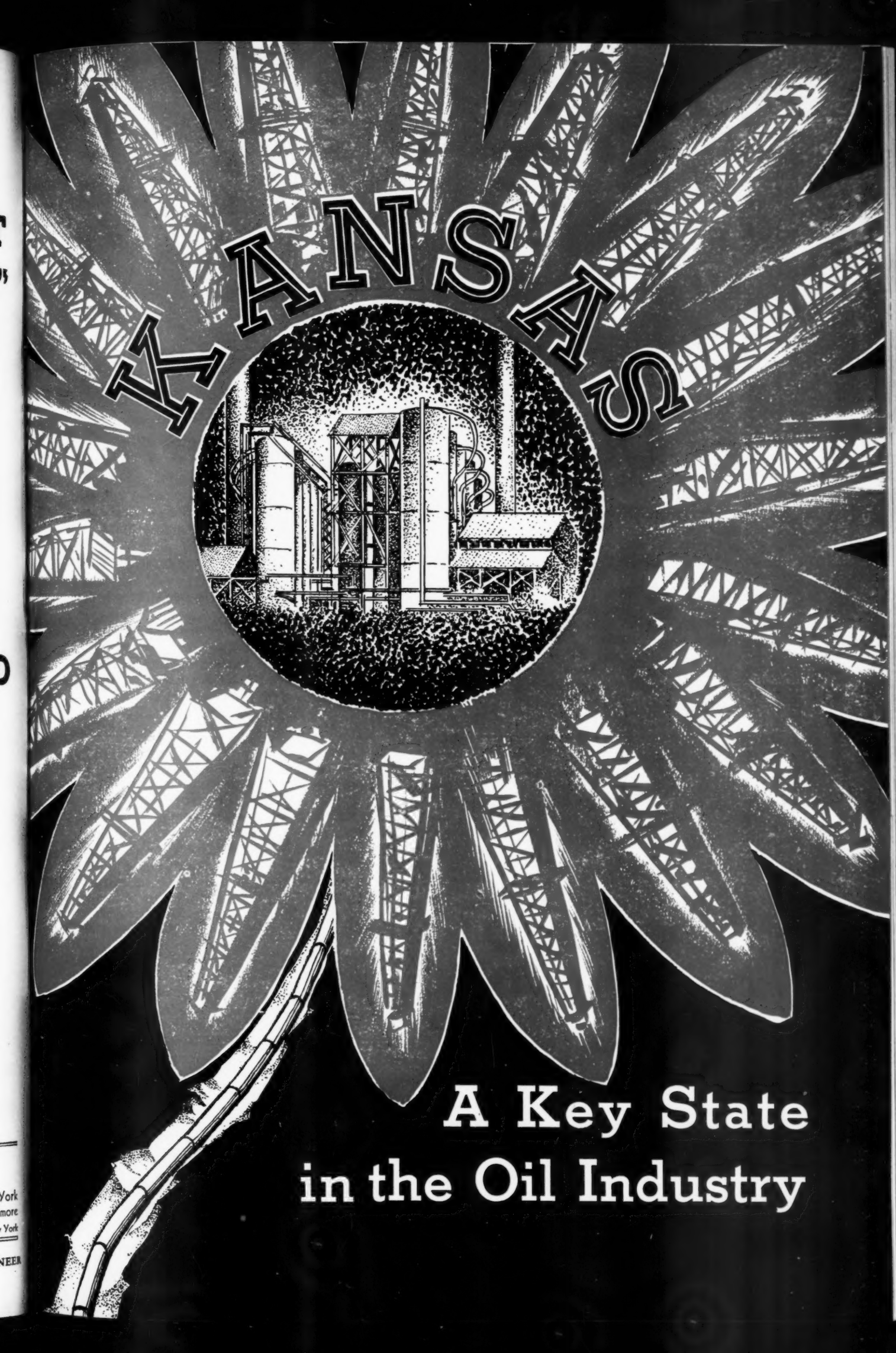

KANSAS
A Key State
in the Oil Industry

Drawworks mounted as a unit on steel skids and with protective metal covering in use in Kansas fields

By
K. C. SCLATER

Progress Marks Development of Kansas Fields

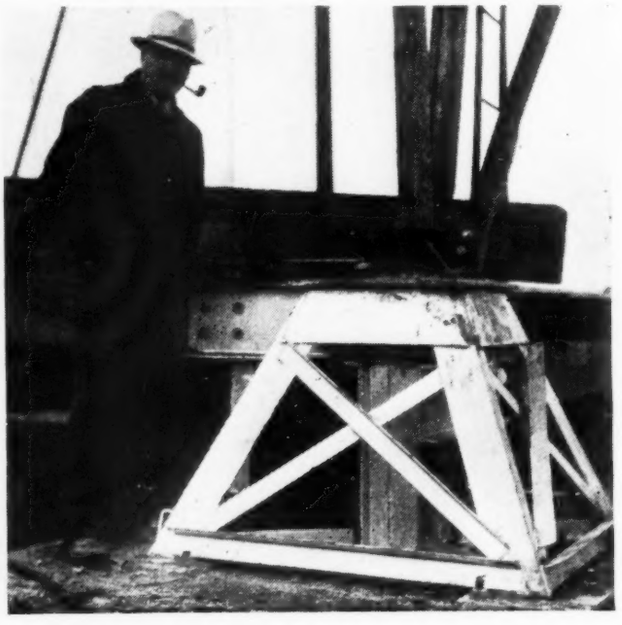
ALTHOUGH the southeastern corner of Kansas is one of the oldest producing areas in the Mid-Continent, it is only within the last eight or nine years that the vast oil possibilities of the western part of the state have really been discovered.

There are many progressive features pertaining to the development of these fields that are worthy of mention, not the least of which is the enlightened method of state regulation and control of oil production. Earnest efforts have been and are being made by the state umpire and his staff, who are charged with seeing that the state oil rules and regulations are complied with, to find a method of allocating allowables that will be equitable.

Potential as defined by the state of Kansas is the daily capacity of a well or lease to produce as determined by the rules and regulations. Among the more important of these regulations pertaining to the determination of potential are, that all wells be tested in the manner in which they are normally produced, namely, flowing wells to be produced by natural flow; and pumping wells by pumping through not greater than 3-in. tubing, not greater than a 3-in. working barrel, and with a length of stroke not greater than 54 inches. The use of larger than standard oversize valves is prohibited. Swabbing and gas-lift are not permitted in making a potential test.

The period of the test varies according to the size of the well, as follows:

5 to 100 bbl. a day
4-day test
100 to 200 bbl. a day
3-day test
200 to 500 bbl. a day
2-day test
500 or more bbl. a day
1-day test



Portable structural steel derrick corner on a drilling well in the Burrton pool, Kansas

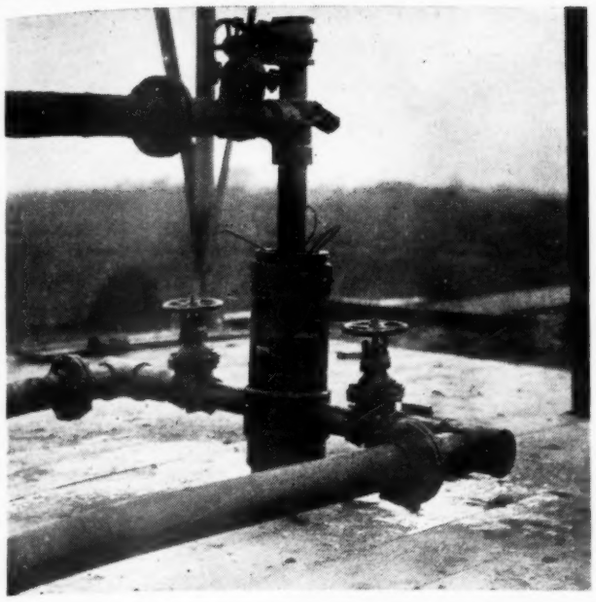
Greater equity in establishing a well's potential capacity to produce, it is realized, would be obtained if the period of test were the same for all wells or perhaps if the period of test instead of being shorter were longer for the larger wells. Lack of pipe line facilities and storage difficulties, however, have been the main reasons for making the period of test shorter on the larger wells.

The percentage allowable allocated to wells are graduated according to the classification of the wells as to size. For the month of December, for example, the allowable varies from 7.35 per cent of potential for large wells, or those in the highest clasification (3250 to 3350 bbl. a day), to 88.52 per cent of potential for small wells (5 to 10 bbl. a day), or those in the classification next to the lowest. The wells in the lowest classification, five bbl. a day or less, are allowed 100 per cent of their potential. In other words, their flow is not restricted. In this classification alone there are 14,059 wells out of a total of 19,381, or almost 73 per cent of the total wells in the state. Allowables are revised monthly to conform with federal allocations.

This method of allocating allowables is an approach to something that is fundamentally more sound than and a great improvement over the conventional method of allocating allowables on a flat percentage of the potential capacity to flow without considering the size or age of the well, pool or field.

Allocating the allowable as is commonly done at present on tests of the potential capacity to flow, a state may increase its allowable by bringing-in more wells although in so doing its recoverable reserves may not be increased one barrel.

Were recoverable reserves rather than only the potential capacity to produce taken into account in determining allowable production it is quite



Casinghead hook-up on a producing well in the Burrton pool, Kansas

likely that Kansas would stand to benefit. The many isolated pools discovered and the spotted nature of the production leads to the belief that the recoverable reserves in Kansas may be very much greater than the number of new wells completed or their capacity to produce would indicate.

Along with the map on pages 46 and 47, showing the oil fields of the state, is a list of the Kansas oil pools, giving the names of their producing horizons and depths.

All wells in the new areas under development are being drilled by rotary and from the surface to the top of the producing horizon, rock bits are used the entire depth. It is customary practice to drill-in with cable tools. Fear of mudding-off the producing formation and the hazard of a blow-out are among the chief reasons for drilling-in with cable tools.

At least one company has adopted the practice of drilling-in and completing wells with the rotary, apparently with success. This company contends that by keeping the mud in proper condition and exercising proper control of the slush pump and bit pressures, wells can be drilled-in successfully with the rotary. When about 2100 ft. is reached this company makes a practice of thoroughly conditioning the mud and adding Aquagel. A close check is then kept on the mud until the well is completed. It has been the experience of this company that where high pressures are encountered, the danger of mudding the pay horizon is very slight, and that better control of the well is had with the rotary.

An active drilling program is in progress in the Robbins pool south of Wichita. The wells are being drilled by rotary and, like the fields west of Wichita, entirely with rock bits to the top of the producing horizon. One drilling contractor in this field maintains an average drilling speed of 300 ft. a day on wells. He uses a light combination rotary and cable-tool drilling-in outfit mounted on steel skids, and with it completes a well in 19 days. This includes two days standardizing and allowing the cement to set. Only one string of surface casing is used. A 9-in. hole is drilled to the top of the Chat, where 7-in. casing is landed and cemented. The well is then drilled-in with the cable-tool drilling-in unit. These drilling-in units are discussed and illustrated in another article in this section.

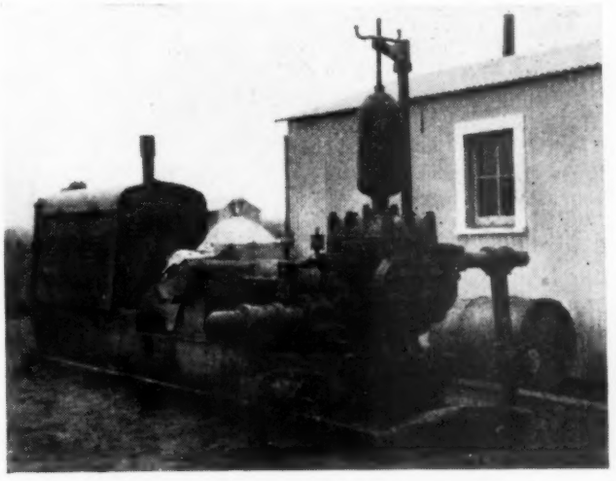
The use of these portable steel drilling-in units is one of the notable progressive features of Kansas drilling practice. Time is saved in moving and rigging up by mounting rotary drawworks and engines on steel skids. Some operators now are enclosing the entire drawworks in a welded metal cover, as is shown on the illustration at the top of page 44.

In order to reduce costs and better to equip the well for pumping, one company in the field is using derrick corners of structural steel in place of the large combination concrete bases in common use. These structural steel derrick corners are portable and can be moved along with the rotary to another location. They are three ft. in height and of sturdy construction, and are strong enough to support twice the maximum load of the derrick.

The steel corners in use (see illustration) rest on 7 ft. by 7 ft. by 2½ ft. concrete blocks, which are set two ft. in the ground with the top only six in. above ground level.

After the well is drilled the steel corners, and also the floor and cellar timbers, can be moved to a new location. A concrete flow is laid, the top the same height as the concrete corners, preparatory to putting the well on the pump. A neat derrick floor of concrete at ground level, with modern steel pumping equipment, makes an efficient type of pumping well installation that is free from fire hazard.

Acid-treating, an important and progressive phase of producing operations in Kansas, because of the producing formations being predominantly limestone, is interestingly discussed in another article in this section.



Gathering line pump in the Burrton pool

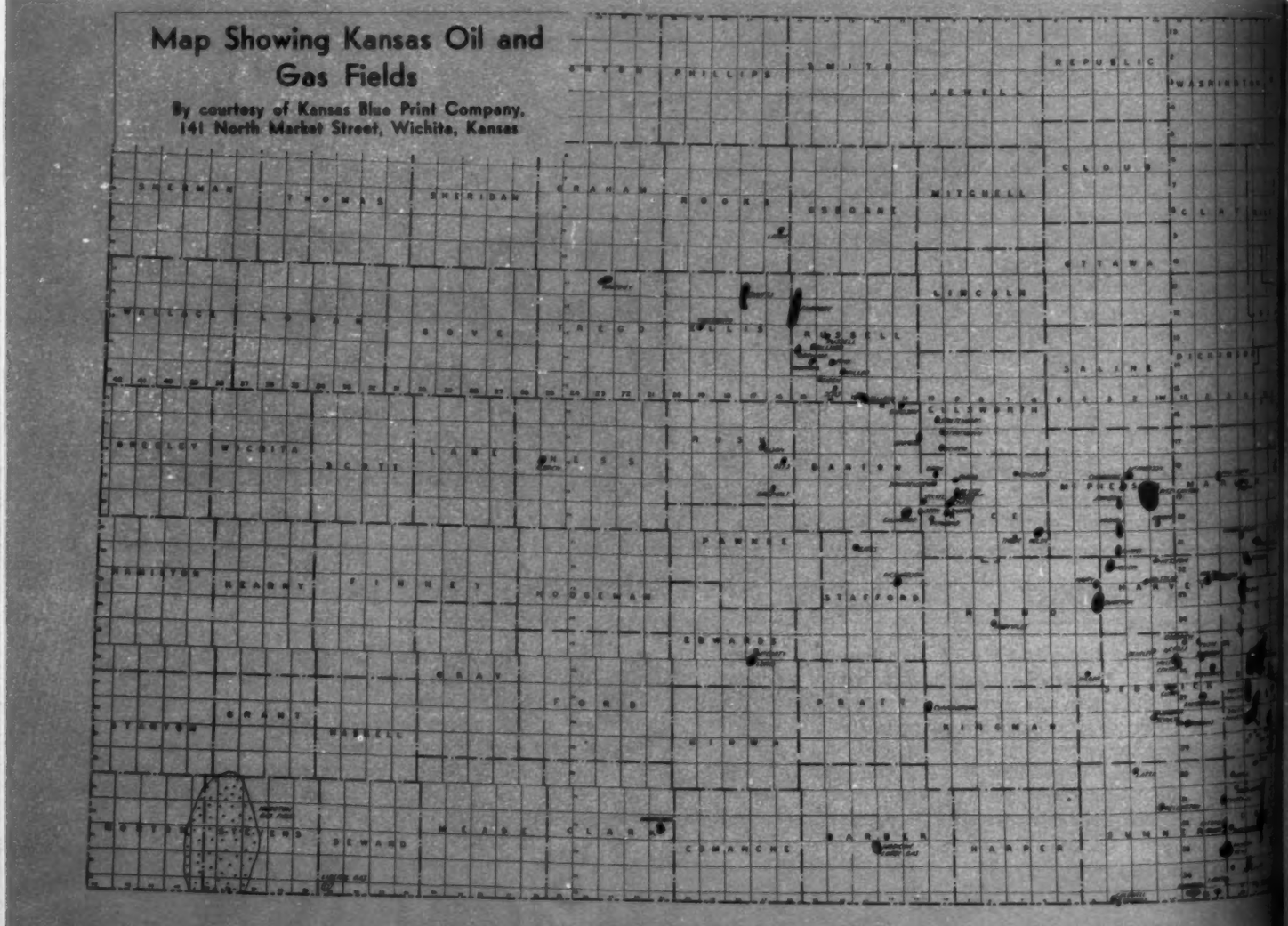
Scattered Pools Offer Pipe Line Problems in Kansas

OIL pipe line facilities are somewhat limited in certain sections of western Kansas. Oil development has taken place over a wide area and pools are scattered. The spotted nature of the development and the irregular yield from many of the pools that have been discovered add an element of risk and uncertainty that does not favor or justify extensive pipe line construction programs at this time. Neither have the unstable conditions within the industry itself, combined with the month-to-month curtailment regulations, been conducive to planning transportation facilities very far ahead of anticipated development.

Immediate transportation needs are only being taken care of. Further field development operations, which are expected to continue on an increasingly larger scale, probably will justify additions to the present system of gathering and trunk lines.

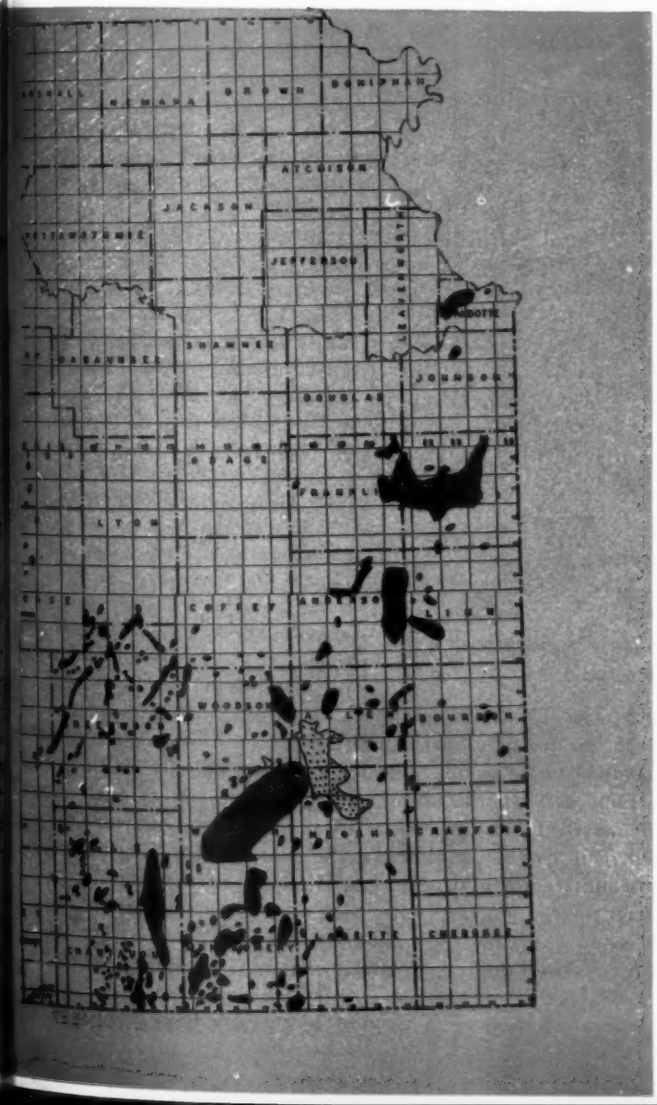
NAMES OF KANSAS OIL POOLS, SHOWING PRODUCING HORIZONS

Pool	County	Producing Horizon Local Usage	Approximate Depth Topped
Abbyville	Reno Greenwood	Lansing-Kans. City	3200
Atyeo-Pixlee	Lyon	Bartlesville Sand	2505
Augusta, North	Butler	Lansing-Kans. City	KC–2000–2100
		Viola Arbuckle	2300–2400
Augusta, South	Butler	Lansing-Kans. City	KC–2000–2150
		Viola-Wilcox	2550–2600
		Arbuckle	
Bentley	Sedgwick	Kansas City	2700
Benton	Butler	Chat	2850
Beyer	Rice	Conglomerate	3180
		Arbuckle	3213
Brandenstein	Rice	Lansing-Kans. City	3100
Breford	Ellsworth	Arbuckle	3352
Browning	Greenwood	Bartlesville	2035
Burden	Cowley	Bartlesville	2950–3050
Burkett	Greenwood	Bartlesville	6950
Burrton	Reno	Chat	3250
		Hunton	3570
Caldwell	Sumner	Simpson Sand	4769–4900
Slick-Carson	Cowley	Kansas City	2600
		Arbuckle	3450–3500
Chase	Rice	Lansing	2920
		Arbuckle	3230
Churchill	Sumner	Hoover Sand	1600
		Stalnaker Sand	1850
Clark	Cowley	Bartlesville Sand	2850
Climax	Greenwood	Mississippi Lime	1850
Coffey (Misc.)		Coffee	
Covert-Sellers	Marion	Kansas City	
		Viola	2350–2400
Cowley (Misc.)	Cowley	Lansing-Kans. City	
		Bartlesville	
		Mississippi Lime	
		Arbuckle	
Cross	Sedgwick	Kansas City	2650
Cunningham	Kingman	Lansing-Kans. City	3405
		Arbuckle	4100
DeMalorie-Souder	Greenwood	Bartlesville	2125
Denton	Elk	Mississippi Lime	2800
Dillner	Russell	Arbuckle	3300
Douglas	Butler	Kansas City	1950
Eastborough	Sedgwick	Mississippi Lime	2949
		Viola	3148
		Misener	3231
Eastman	Cowley	Bartlesville	2830–2900
Eastern Ks. (Shallow)			
Elbing	Butler	Kansas City	2000–2180
		Viola Arbuckle	2400–2450
Eldorado	Butler	Lansing-Kans. City	1700–2000
		Fort Scott	2100–2200
		Viola-Wilcox	2600–2750
		Arbuckle	2400–2500
Elk, West (Misc.)			
Ellinwood	Barton	Arbuckle	3290–3350
Eureka Townsite	Greenwood Russell	Mississippi Lime	1950–2000
Fairport	Ellis	Oswald Lime	2920
Fall City	Cowley	Kansas City	2700
Fankhouser	Greenwood	Bartlesville	1880
Florence-Urschell	Marion	Viola Arbuckle	2300–2400 –
Fox-Bush	Butler	Bartlesville	2700
Garden-Shaffer	Butler	Bartlesville	2710
Gates	Stafford	Arbuckle	3560–3620
Geneseo	Rice	Arbuckle	3140
Giden	Russell	Arbuckle	3308
Goodrich	Sedgwick	Kansas City	2585
		Simpson Dolomite	3450
Gorham	Russell	Oswald	3080
		Penn. Conglomerate	3310–3320
		Arbuckle	3310–3320
Graber	McPherson	Hunton	3274
Graham	Cowley	Kansas City	2550–2575 2500–2600
		Arbuckle	3500



AND THEIR APPROXIMATE DEPTHS

Pool	County	Producing Horizon Local Usage	Approximate Depth Topped
Greenwich	Sedgwick	Chat	2865
		Viola	3160
Greenwood (Misc.)			
Grove	Rice	Arbuckle	3200
Halstead	Harvey	Chat	2957
Hamilton	Greenwood	Bartlesville	1880
Hanna	Elk	Bartlesville	2065–2100
Haury	Reno	Chat	3250
		Hunton	3570
Haverhill	Butler	Bartlesville	2688
Hazlette	Butler	Chat	2400–70
Heiken	Ellsworth	Arbuckle	3206–40
Hesston	Harvey	Hunton	3310
Hilger	Reno	Hunton	4062
Hillsboro	Marion	Viola	2890
Hittle	Cowley	Kansas City	2325–75
Hollow	McPherson	Chat	3130
		Hunton	3400
		Simpson Sand	3500–3550
Howard	Elk	Kansas City	1800
		Mississippi Lime	2100–2150
Isern	Barton	Arbuckle	3294
Johnson	McPherson	Chat	3014
Kechi	Sedgwick	Chat	2900
Keighley	Butler	Bartlesville	2650
Kramer	Butler	Viola	3050
Kuske	Sedgwick	Chat	3013
Lamont	Greenwood	Bartlesville	1685–1700
Laton	Rooks	Oswald	3255
Latta	Sumner	Lansing-Kans. City	3025
Leon	Butler	Bartlesville	2680
		Viola	3078
Lost Springs	Marion	Chat	2400
Madison	Greenwood	Bartlesville Sand	1850
McCarty	Edwards	Chat	4450–4600
McPherson	McPherson	Kansas City	2300
		Chat	2850
Miller	Russell	Arbuckle	3030



Pool	County	Producing Horizon Local Usage	Approximate Depth Topped
Moline Townsite	Elk	Kansas City	1250–1300
		Oswego	1650
		Arbuckle	2300
Niedenthal	McPherson	Arbuckle	3246
Nikkel	McPherson	Chat	3150
		Hunton	3476
Ochs	Russell	Arbuckle	3361
Orth	Rice	Arbuckle	3250
Otis	Rush	Penn. Conglomerate	3500
Oxford	Sumner	Hoover	1610–70
		Stalnaker	1960–2090
Oxford, West	Sumner	Arbuckle	3700
Padgett	Sumner	Bartlesville	3350
		Chat	3450
Peabody		Kansas City	1850
		Viola	2420–2500
Ploog	Rice	Arbuckle	3253
Potwin	Butler		
	Woodson	Chat	2650
Quincy	Greenwood	Bartlesville	1540
		Chat	1635
Rainbow Bend	Cowley		
	Sumner	Bartlesville	3200
		Arbuckle	3530
Rapp	Sedgwick	Chat	2865
Raymond	Rice	Kansas City	3120
		Arbuckle	3278–3300
Reece	Greenwood	Mississippi Lime	2400
Richardson	Stafford	Arbuckle	3540
Ritz	McPherson	Chat	2000–3000
		Viola	3350–3450
Rock	Cowley	Bartlesville	2770
Robbins	Sedgwick	Mississippi Lime	3075
Russell	Russell	Arbuckle	3262
Sallyards	Butler		
	Greenwood	Bartlesville	2315
Schulte	Sedgwick	Misener	3650–52
Scott	Greenwood	Bartlesville	2570
Seeley	Greenwood	Bartlesville	1940
Sellens	Russell	Arbuckle	3348
Severy	Greenwood	Bartlesville	2085
Sharpe	Rice	Arbuckle	3325
Shutts	Ellis	Oswald	3460
		Arbuckle	3632
Smith-Shaffer	Cowley	Bartlesville	3040–3060
Smock-Sluss	Butler	Bartlesville	2674
State	Cowley	Lansing	2300
		Arbuckle	3300
Steckel	Rice	Arbuckle	3299
Steinhoff	Butler	Kansas City	2250
Stoltenberg	Ellsworth	Arbuckle	3347
Stone		Chat	3113
Stratmann	Ellsworth	Arbuckle	3267
Straub	Barton	Arbuckle	3280
Sumner (Misc.)			
Teter	Greenwood	Bartlesville	2950
Thode	Rice	Chat	3397
Thrall	Greenwood	Chat	2110
Valley Center	Sedgwick	Kansas City	2565
		Simpson Dolomite	3470
Virgil	Greenwood	Bartlesville Sand	1550
		Mississippi Lime	1780
Voshell	McPherson	Chat	2990
		Viola	2260–3355
		Misener	
		Wilcox	3295–3395
		Arbuckle	3465
Walton	Harvey	Chat	2885
		Kansas City	2200
Weaver	Butler	Bartlesville	2688
Webb	Elk	Webb Sand	1100
		Kansas City	1330
		Oswego	1620–48
Webster	Rooks	Oswald	3165
Welsh	Rice	Chat	3396
Wellington	Sumner	Chat	3640
Whelan	Barbour	Chat	4355
Wiggins	Greenwood	Cattleman's Sand	1860
Wilkerson	Greenwood	Bartlesville	2215
Wilkins	Ellsworth	Arbuckle	3255
Winfield, East	Cowley	Layton Sand	2300
		Bartlesville	2900
Winfield Townsite	Cowley	Layton Sand	2300
		Arbuckle	3300
Wintercheid	Woodson	Mississippi Lime	1700
Woodson (Misc.)			
Yocemento	Ellis	Oswald	3455
Young	Butler	Kansas City	2700
		Chat	3050

Special Kansas Section

Acid Treatment in Kansas Fields

L. C. MORGAN

Some New Aspects of Acid-Treating Practice

By L. C. MORGAN*

THE principal object of treating a well with acid is to utilize the available reservoir energy so that the rate of production of the well may be increased, be its production oil, gas, or both. To date, with the exception of a recent paper,[1] the available publications studied by the writer discussing this subject, are limited to a strictly chemical viewpoint or to that of the practical production man. While endeavoring to keep the practical attitude, this paper will attempt a correlation between bottom-hole consideration and field practice, using examples from Kansas fields.

Herold, in his excellent exposition of production principles, classifies reservoirs according to their source of energy as: (1) Hydraulic control, (2) volumetric control, (3) capillary control, or a combination of them. Assuming his premises to be sound, in any theoretical study of acid treatment great stress should be placed on the utilization of this energy.

The actual work done by acid is to bring about the solution of the reservoir material and thus increase the porosity of the reservoir and from this, its permeability.

In a well producing from a reservoir in hydraulic control, the bottom-hole pressure will remain constant, and the rate of production of any given fluid ratio between oil and water will remain constant. In treating this type of well with acid, the logical effort should be to increase the porosity of the area immediately surrounding the bore hole, the results from which would be the same as enlarging the radius of the hole, for we know that other conditions remaining the same, the rate of production varies proportionately as the radius of the hole. Kansas examples of this are the Hunton Lime reservoir in the Nikkel Pool, Viola Lime reservoirs in Northern Butler County, and much of the Siliceous (Arbuckle) Lime production throughout Kansas.

In a well producing from a reservoir under volumetric control, the bottom-hole pressure will decrease to zero in finite time and production will cease. From a theoretical view, in treating this type of well with acid we should determine the lowest producing well for a definite drainage area and successively increase its drainage area by repeated acid treatments. Examples of fields producing under these conditions without hydrostatic control in one part of the field, or evidence of capillary control in another, are very difficult to find; however, the Viola Lime horizon of the central and western part of the Ritz-Canton field and the Hunton Lime production in the Hollow field are examples at the present time. In these fields the first acid treatment work was very successful and the dominating source of reservoir energy was difficult to recognize; probably it was capillary as first drilled but now, after much acid treatment work, the wells behave as if the pool were under volumetric control.

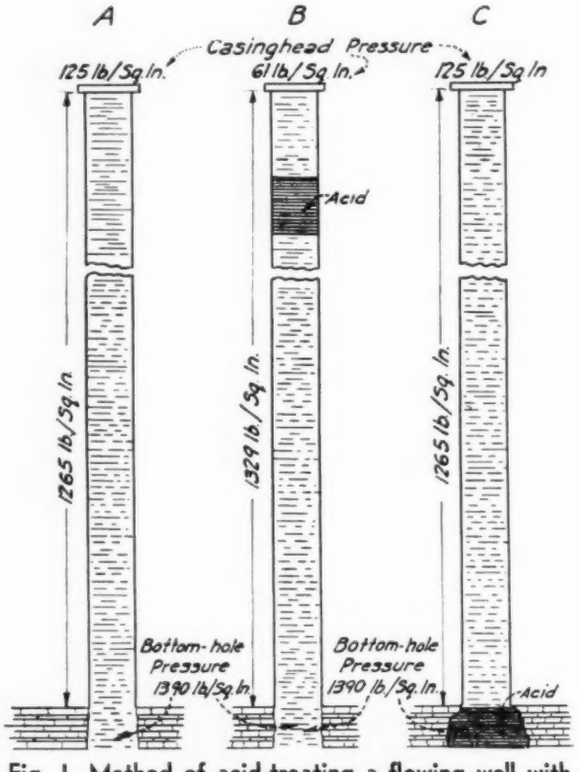


Fig. 1. Method of acid-treating a flowing well with a balanced column of fluid

In a well producing from a pool under capillary control, bottom-hole pressure and rate of production approach zero in finite time as exemplified by the Jamin capillary tube, a tube of capillary bore, filled with alternating globules of oil and gas. If with our acid work, we increase the porosity of the reservoir rock, we likewise increase the size of the bore in our exemplified capillary tube and permit the passage of fluids. In theory, this type of reservoir benefits most from acid treatment, especially considering ultimate yield. Excepting consideration of minimum production for economic operation, wells producing under conditions of hydrostatic and volumetric control should produce as much oil without the use of acid as with the use of acid. Acid treatment merely increases their rate of production and not their ultimate yield. The gain by the use of acid is the reduction of the compound discount factor in determining the value of the field. An apparent exception to this has been noticed by the writer; however, he explains it by capillary control influence. For example, a well under hydrostatic control is producing 100 bbl.

*The Morgan Petroleum Engineering Company, Wichita, Kansas.

[1] "Acid Treatment of Michigan Oil Wells," by K. A. Covell. A.P.I. Mid-Year Meeting, Pittsburgh, May 22-24, 1934.

water and two bbl. oil per day. As much water as possible is exhausted and a large amount of concentrated acid is placed in the well and expelled from the bore hole. When the well is pumped again, an increase in oil-water ratio is noted. The writer accounts for this by the belief that a body of oil was trapped through Jamin action near the well and the action of the acid permitted the oil to move to the well.

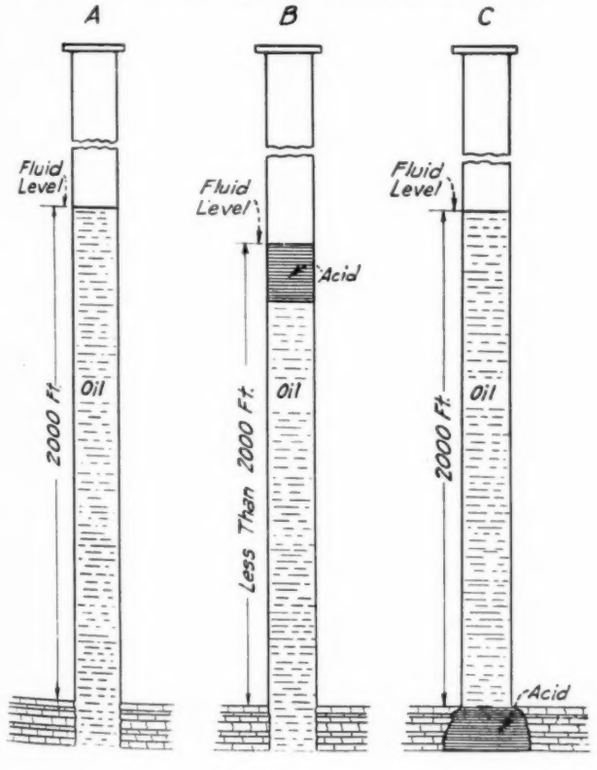
In the treatment of the capillary reservoir, the writer believes that the area around the well should be considered as successive zones to be treated. For example, in a dolomite, in rapidly expelling the acid into the producing formation with such an amount of oil that causes the acid to come to rest some distance from the well, if the formation immediately surrounding the well and through which the acid passes has not been previously treated, in large wells, frequently no increase in the rate of production is noted. The writer explains this in that the rate of reaction is so slow that the acid passes through the untreated area without increasing its effective porosity.

From the above example and by similar reasoning, to get the best results, bottom-hole conditions in the individual well must be studied, either directly by use of the bottom-hole bomb or synthetically by a study of the fluid level, temperature, gas-oil ratio, etc.

We must bear in mind that areas of the producing horizon around the well, effectively treated with acid, will probably function under volumetric control though the remaining area may be under capillary control.

In the treatment of flowing wells or large wells (especially newly drilled) having low gas-oil ratios and acting as though under the influence of hydraulic control, the writer recommends the use of the so-called big-hole method. He calls the following the balanced column method. The bottom-hole pressure is determined with the well shut in. The volume of oil to fill the pipe to equalize this pressure is then determined, both gravity and temperature being taken into account. The acid is then placed in the hole and the determined amount of oil added. Because of the difference in specific gravity, the acid-oil interface seems to act as an effective barrier preventing the mingling of the acid and oil. Fig. 1 is offered in further explanation of this method.

Fig. 2. Method of acid-treating with a balanced column of fluid a well having insufficient pressure to flow



The data are taken from an actual case of a flowing well in the Hunton Lime producing area in Kansas. Total depth is 3598 feet. Fig. 1-A shows the well shut in and accumulated gas blown off. Well head shows 125 lb. per sq. in. pressure and the pressure due to the weight of oil column is 1265 lb. per sq. inch. Acid is then pumped into hole, increasing the weight of the column to give a pressure of 1329 lb. per sq. in., and the well-head pressure reduces to 61 lb. per sq. in. (Fig. 1-B). When the calculated amount of oil to fill the casing is pumped in after the acid, the well-head pressure then returns to 125 lb. per sq. in. (Fig. 1-C.)

In applying this method to wells without sufficient pressure to flow, the field method is to determine the bottom-hole pressure directly; or indirectly by determining the fluid level during swabbing. In a manner the same as that previously described, acid is then pumped into the well followed by the necessary volume of oil to displace the acid and equal to the previously determined fluid level. Fig. 2 is offered in further explanation of this method.

Fig. 2-A shows a well with a fluid level of 2000 ft.; in Fig. 2-B, acid is added through the casing, and results in lowering the fluid level; in Fig. 2-C, an amount of oil equal in volume to that contained in the hole at the level of Fig. 2-A is added, expelling the acid into the formation immediately surrounding the well.

For successive acid treatments, additional oil would be added following the acid, depending, in each case, on the position of the acid desired, taking into consideration, however, the bottom-hole pressure at the time of each treatment.

In this application, as mentioned before, we should consider the area surrounding the bottom of the hole as concentric zones of equal volume. With the ideal case, in any horizontal plane, we would have a series of circles with a common center, the center representing the well, with each annulus between the circles of equal area. In the field of application, because of variations in porosity, the plan of the horizontal plane will probably be a series of concentric amoebic looking figures. In the discussion of these successive zones or annuli surrounding the well, consideration should also be given to the probability that there may be great vertical variation in the position of these zones for any one particular volume; that is, the vertical variation of one particular zone may reveal different positions in different horizontal planes. We should further consider, in our second and successive treatment, the volume of reservoir rock displaced by the chemical action of previous treatments; also the amount of unconsolidated insolubles, manifesting themselves as floating sand, etc.

In each successive treatment, the volume of solution used in treating is a constant, if we consider the radius of our theoretical circle as R_1, treatment number as n, the distance (d) reached will be

$$d = \sqrt{n}\, R_1$$

For example, if the first radius is 12 ft.; the second will be 16.96 ft.; the third will be 20.78 ft.; the fourth, 24 feet. This example shows us that it is good practice to increase the volume of our treating solution as we increase the distance from the well.

Calcite-Dolomite Problem

In many of the horizons treated, the reservoir material may have vertical and horizontal variations of calcite and dolomite. When the oil is contained in the calcite, the evidence of failure is not so apparent as when the dolomite is the reservoir rock and the calcite is barren.

To obtain the greatest efficiency when calcite and dolomite both constitute the reservoir material an effort should be made to increase the rate of reaction of the acid on the dolomite. HCl solutions react with calcite readily at cold and

medium temperatures. In Kansas cases studied by the author, the increased rate of reaction on dolomite of HCl solutions as used in acid-treating starts at 44 to 46 deg. cent. (111-115 deg. fahr.). By this property, raising the temperature of the reacting acid and using a method to maintain the increased temperature at the bottom of the hole, constitutes a practical solution of this problem.

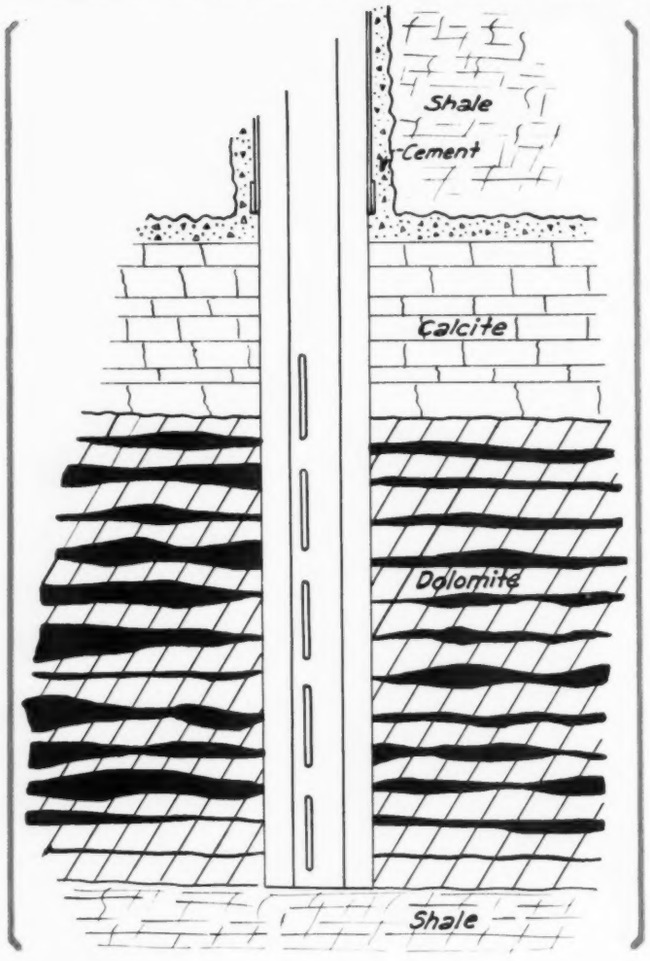
The most frequent failures in this class are those where the oil is held in dolomite in the presence of calcite. Fig. 3 shows an example of this condition in the Hollow Pool Hunton Lime reservoir. The hole is shown with the pipe cemented on the top of the pay in the "Misner Sand." Tubing is shown in the hole for treating by the tubing method. From studies of the drill cuttings, the upper few feet of the Hunton in several wells in this pool is barren crystalline calcite. The oil is contained in the underlying dolomite.

The wells were treated with cold acid by the so-called tubing method. The treatment was considered a failure and in one case the well was treated, shot with glycerine, and treated twice more, without results. The well was then treated with hot acid, and resulted in a very substantial increase in the rate of production, which increase held up over a period of a year. This practice was then repeated on a number of other Hunton Lime failures and resulted in consistent, favorable results in eight out of ten cases of former failure. As far as the writer knows, he was the first to use the so-called "hot shot" in Kansas.

Character and Volume of Solution

Why the 1000-gallon treatment has become a yardstick in acid-treating practice has unquestionably entered the minds of most interested people. As near as the writer has been able to find out, this volume was consistent with successful results in the Michigan field, and through competition became the standard in other fields.

Fig. 3. Many Hunton Lime wells in Kansas produced from a dolomitic formation, as shown here, require frequent treatment with hot acid to obtain successful results



An unlimited amount of debate could be had on the question as to what is the optimum volume of treating solution to use on each well. Should six inches of pay take as much acid as sixty feet?

With concentration of solution as with volume, we are divided into at least two schools of thought.

With the volume question, one school believes treat first with 250 gal., then 500 gal., then 1000 gal., and so on. The other school says start with 1000 gal. or 2000 gal., and repeat the same amount. The writer, as mentioned before, believes that the extent of the depletion of reservoir energy, condition of physical equipment (whether corroded or otherwise defective) are very important considerations as well as thickness of pay, original porosity and permeability.

With the problem of the proper concentration of the solution, there are also two divisions of opinion. Those that believe in weak solutions, 100-180 gal. 18 deg. Baumé concentrated, HCl for 1000 gal. total solution; and those who believe in stronger solutions, 300-600 gal. 18 deg. Baumé concentrated HCl for 1000 gal. total solution. The writer believes that beyond abstract speculation, the amount of water produced with the oil, the amount of gas movement to be expected in the hole, and the character of the formation should be the determining factors; his empirical studies point to this conclusion.

An important factor in successful work is to remove as much water from the hole as possible before acid treating is attempted. A large volume of water dilutes the acid and often prevents the acid reaction from taking place at the desired position. Methods for overcoming this in the field are: Keeping the hole filled with oil and pumping off accumulated water for several days before treating; circulating water out of the hole through the tubing by forcing oil down through the casing in cases where the fluid level permits and there exists a sufficiently low degree of permeability around the bottom of the hole; keeping the well pumped down until ready to put the acid in the well; and using sufficient concentrated HCl solution to mix with the water and yet obtain the proper reaction.

Though it may appear to be "putting the cart before the horse," with the foregoing description in mind and considering previously published papers and patent files, we might attempt a classification of acid treatment methods, based on the use of equipment:

1. Big-Hole Method
   (a) Random displacement of treating solution
   (b) Balanced column
2. Tubing Method
   (a) Without hole filled
   (b) With hole filled

Based on chemistry:

1. Strong solutions
2. Weak solutions
3. Solutions used in which an effort is made to control temperature

Based on volumes of oil and acid used:

1. Small volume of treating solution
   (a) Displaced from hole
   (b) Displaced with a large volume of oil
2. Large volume of treating solution
   (a) Displaced from hole
   (b) Displaced with a large volume of oil

The use of the so-called blanket, brine seal, etc., based both on the theory of heavy solutions below the acid and the theory of chemical principitates has been advocated by some and discouraged by others. In Kansas, most operators have found the use of the so-called blankets unnecessary because of the lack of ability to determine the final position of the blanket in the hole.

Refining Practice at McPherson Plant of Globe Oil & Refining Co.

By N. K. HOPP

Chief Chemist, The
Globe Oil & Refining Company

High-pressure and high-temperature lines in the foreground. Flash tower, vapor separator, and pressure-distillate bubble tower in the background, at refinery of the Globe Oil and Refining Co., McPherson, Kansas.

IN operation since about April, 1933, the McPherson refinery of the Globe Oil and Refining Company is running on Chase (Rice County) and McPherson County crude. The gravity of McPherson County crude ranges from 36 to 39 deg. A.P.I. and that of the Chase crude from 41 to 44 degrees. Oil is taken from the crude storage tanks and pumped through heat exchangers where it exchanges heat with hot pressure distillate and Lachman treated gasoline, and thence to water and salt settlers where all water and some of the salt is removed. From the water settlers it passes into the crude debutanizer where the last traces of water and the extremely volatile fractions in the crude are removed. The secondary crude pump takes suction from the bottom of the crude debutanizer and discharges through enclosed type exchangers situated in the vapor separator and in the pressure distillate bubble tower and finally to the flash tower, after having picked up enough heat to enable thorough fractionation to take place in the flash tower. The flash tower is 9 ft. by 93 ft. The straight run gasoline is taken from the flash tower as the overhead stream. The naphtha, kerosene distillate, and gas oil fractions are taken from the tower as side streams. Strippers (4 ft. by 18 ft.) are provided as auxiliary fractionators for the side streams so as to regulate closely the boiling range of the side streams. The tower is capable of cutting the different streams very closely without overlapping of the initial and final boiling points of two consecutive products. The flash tower streams discharge through condenser coils, and gas and water separators to the run down tanks for subsequent processing. A portion of each condensed stream is utilized for reflux.

The cracking equipment is of the Winkler-Koch multi-coil type. A Worthington hot oil pump takes suction from the bottom of the pressure distillate bubble tower and discharges into the coils in the No. 1 furnace. Economizers are used to preheat air utilized in the combustion of gas in the furnaces. After passing through the preheater coils, roof tubes, and final coils, the oil is passed through a transfer line and control valve. Pressures from 400 to 500 lb. and temperatures from 910 to 960 deg. fahr. are held on the transfer line, or the hot oil outlet. After passing through the control valve the oil passes into the vapor separator. The fraction of the oil containing gas-oil and lighter is flashed overhead and into the pressure distillate bubble tower, which is an 11-ft. by 75-ft., 15-tray, bubble tower where the raw pressure distillate is removed as an overhead cut. The hot P.D. vapors pass through crude heat exchangers to the Lachman contact tower, a portion of the P.D. being condensed and used as reflux. A naphtha, or high-pressure stripper stock is taken from the P.D. bubble tower and passed into a smaller fractionater known as a high-pressure stripper. Another Worthington hot oil pump takes suction from the bottom of the high pressure stripper and discharges it into the coils of the No. 2 furnace. This furnace is identical with the No. 1 furnace; however, temperatures from 970 to 1050 deg. fahr., and pressures of from 200 to 500 lb. are held on the hot oil outlet. The oil from the No. 2 coil discharges into a transfer line through a pressure control valve and into the vapor separator along with the oil from the No. 1 furnace coil.

The residuum is passed from the bottom of the vapor separator to the vacuum tower, where it is reduced to a low-gravity pitch. The pitch is then blended with a distillate to the desired viscosity.

The raw pressure distillate, ranging in color from 6 (Saybolt) to 19 (Saybolt) and containing from 300 to 900 Mg. copper dish gum is passed into the contact tower of the Lachman treater in the vapor phase. Here it is contacted with an aqueous solution of zinc chloride. Any hydrogen sulphide present in the P.D. reacts with the zinc chloride to form zinc sulphide and hydrochloric acid. The action of the zinc chloride on the gasoline is catalytic, polymerizing the gum-forming constituents, which are drawn from the tower together with a sludge of zinc sulphide, zinc oxychloride, and zinc chloride. Most of the hydrochloric acid formed is removed as the gasoline vapors pass through towers filled with a relatively soft, pure grade of lime rock. Any acid not removed in the rock towers is neutralized with an aqueous solution of ammonia after the gasoline enters the Lachman final bubble tower, where final adjustment of the end-point is made. From the Lachman final bubble tower the gasoline passes through heat exchangers, condensers, and final coolers, and thence to the Lachman gasoline debutanizer where it is denuded of the undesir-

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able lighter fractions. A portion of the condensed stream from the final bubble tower is used as reflux. From the Lachman gasoline stabilizer the gasoline passes to run down tanks for subsequent doctor-sweetening. The final product is 30 plus or minus color (Saybolt) and has a gum content of not more than 10 Mg. by the copper dish method. No depreciation in the octane rating of the gasoline occurs during the Lachman treatment. Heat necessary for the Lachman treating, other than that contained in the P.D., is supplied in the form of superheated exhaust steam, which is fed into the contact tower.

Wet gas is collected from gas separators and reflux drums and conducted to gas-driven, two-stage compressors. The discharge from the first stage of compression passes through an interstage condensor and separator, the condensate being pumped to the light gasoline stabilizer. The gas from the interstage separator passes through the second stage of compression and is discharged directly into the gasoline stabilizer. A pressure of 300 lb. is held on the stabilizer, and the resulting recovery gasoline is a propane-free product having an excellent recovery. The gasoline is discharged from the light gasoline stabilizer reboiler directly to continuous doctor treaters and thence to field storage tanks.

It will be noted that a large portion of the heat required for distillation and processing is supplied through the medium of heat exchangers, which practice makes for efficient economical operation.

Steam for plant consumption is generated in three 500-hp. water-tube boilers, operating at 225 lb. pressure. The plant has its own water wells, which supply water containing approximately 16 grains total hardness. The boiler feed water is treated in a Graver hot process softener to 0.5 grains total hardness.

Three batteries of continuous doctor treaters handle the straight-run, cracked, and recovery gasoline. The kerosene is doctor-treated in two 900-bbl. batch agitators.

Two of the more serious problems that have arisen have been those concerning corrosion in the cracking coil and crude distillation equipment, and the plugging of heat exchangers due to salt deposition in the crude heat exchangers. Both McPherson and Chase crudes contain approximately the same amount of total sulphur, but the Chase crude contains a much larger percentage of free hydrogen sulphide. The sulphur compounds in the Chase crude are relatively unstable, breaking down with the formation of hydrogen sulphide as one of the constituents. This breaking down of the sulphur compounds occurs in the cracking coil. Corrosion in the cracking coil has been eliminated by treatment of the charging stock with calcium hydroxide, 0.17 lb. of calcium hydroxide is used per barrel of charge. Corrosion in the crude debutanizing equipment has been overcome by pumping a weak solution of caustic soda (1 to 2 deg. Bé.) into the crude line as it leaves the Lachman and P.D. exchangers. The hydrogen sulphide content of the gases from the crude debutanizer has been reduced from 1000 to 200 grains per hundred cu. ft. by this treatment.

Gasoline from the flash tower is water-washed to remove a large percentage of the hydrogen sulphide content before it reaches the run down tanks. The remaining hydrogen sulphide is removed by a caustic wash, which operates in series with the continuous treaters.

The McPherson County crude will average approximately ¼ lb. salt per barrel of crude. The salt is held in suspension in the crude, and is evidently protected by a paraffin film that resists the removal of salt by ordinary methods. It is possible to remove the salt by the means of dehydrating chemicals in conjunction with hot water washing, but the cost is prohibitive.

By raising the temperature of the crude to such a point that all the water is flashed from the crude, salt remains in the crude but does not adhere to the exchange tubes. This mode of handling the salt problem has been working advantageously.

Since both Chase and McPherson crudes are mixed base crudes they do not lend themselves readily to the manufacture of asphaltic pitches for road oil and cut back asphalt; however, with the vacuum tower a pitch having good ductility, penetration, and excellent solubilities has been manufactured without affecting the ultimate yields of gasoline and distillates.

The electrical automatic control instruments for the cracking, reforming, and crude distillation units are set in an attractive panel in the control room. Reflux pumps are also located in the control room. A control panel is also located at the compressor plant.

The water wells from which water is obtained for boiler feed water also supply make-up water for the condensing and cooling equipment. A Pritchard tower is used to cool the water returning from the condenser boxes. Steam turbine driven, centrifugal pumps are used to pump water from the hot well over the cooling tower and back to the condenser boxes. Condensed exhaust steam is used as a cooling medium for the water jackets on the compressors and hot oil pumps. A separate cooling tower is used for this purpose.

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Special Kansas Section

Summary of Refining Methods at Derby Plant, Wichita, Kansas

By C. R. BLACK
Refinery Superintendent

THE refinery of the Derby Oil Company at Wichita, Kansas, has a skimming capacity of 10,000 bbl. and a cracking capacity of 3,000 barrels. Its source of crude supply is the Mid-Kansas area embracing the fields of Sedgwick, McPherson, Reno, and Harvey counties.

CHARACTERISTICS OF CRUDE:

Gravity	41.0 deg. A.P.I.
B. S.	0.2%
45% off at	437
56% off at	510
62% off at	560
Color	Green cast
Sulphur	0.3% to 0.4%
Octane No. of 410 EP gasoline	50
Sulphur of 410 EP gasoline	Less than 0.1%
Lead to sweeten EP gasoline	Less than 0.4 lb.

Skimming Plant

Crude is received at the plant by pipe line and stored in floating-roof tanks. It is first put through heat exchangers and the temperature raised to approximately 225 deg. fahr., then through a water settler, and thence through a stabilizer where a cut of 86 to 92 deg. A.P.I. gasoline is taken off. This light cut is taken through the vapor recovery plant for final stabilization and treatment and thence to pressure storage.

The stabilized crude passes through additional heat exchangers to a flash tower where a high test gasoline is taken off, then through heaters and additional towers where naphtha, kerosene, distillate, Diesel fuel, etc. are taken off. The resulting topped crude (24-26 A.P.I.) is pumped to the cracking stills.

All overhead products are run to floating-roof rundown tanks and from there to the agitators for sweetening before pumping to storage or loading.

Anhydrous ammonia is introduced into the fractionating towers in sufficient quantity to keep the streams neutral.

The topped crude from the skimming plant is taken to the cracking plant where 50 to 60 per cent low end-point pressure distillate is produced. This product is stabilized (118 I.B.P.) before going to the acid treaters and from there to the rerun still where the contained gasoline is taken off.

The light cut from the pressure distillate stabilizer together with the cut from the crude stabilizer just mentioned is taken through the vapor recovery plant for final stabilization to the vapor pressure required by season or distination.

Lime, to hold corrosion in check, is introduced into the cracking plant at the charging pump. Seven towers comprise the acid treating plant, the first three of which are used for acid reacting and settling; No. 4 is the water-washing drum, No. 5 the caustic neutralizing tank, and No. 6 and 7 water-washing and settling tanks.

All light oil products are given doctor treatment in agitators. Doctor solutions after use are blown with air to regenerate solutions. This regeneration cuts lead consumption by about 60 per cent.

Severe corrosion difficulties on skimming and cracking plants experienced since the spring of 1933 are overcome by the use of ammonia on the crude battery and lime introduced in the charge to the cracking plant.

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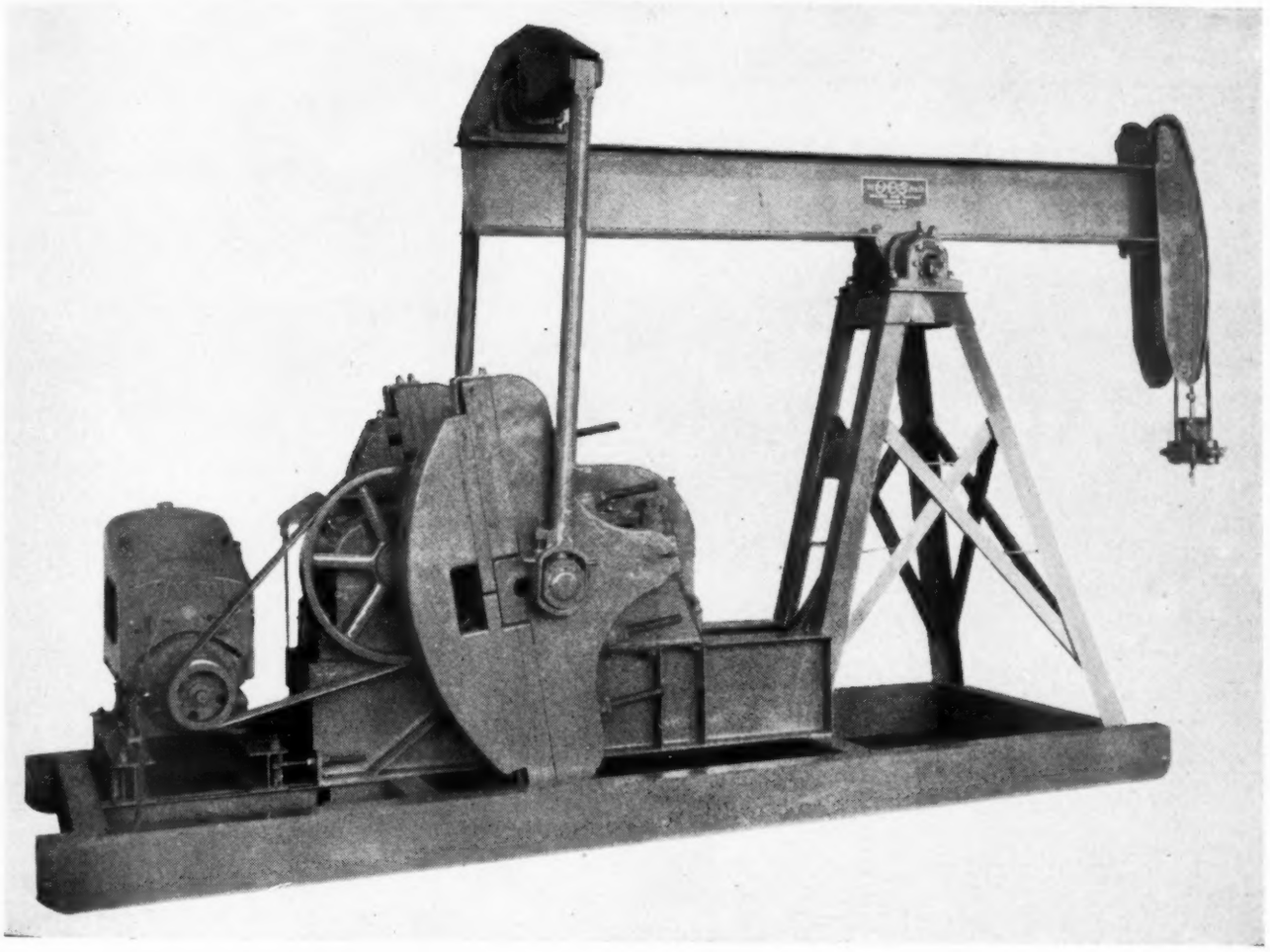

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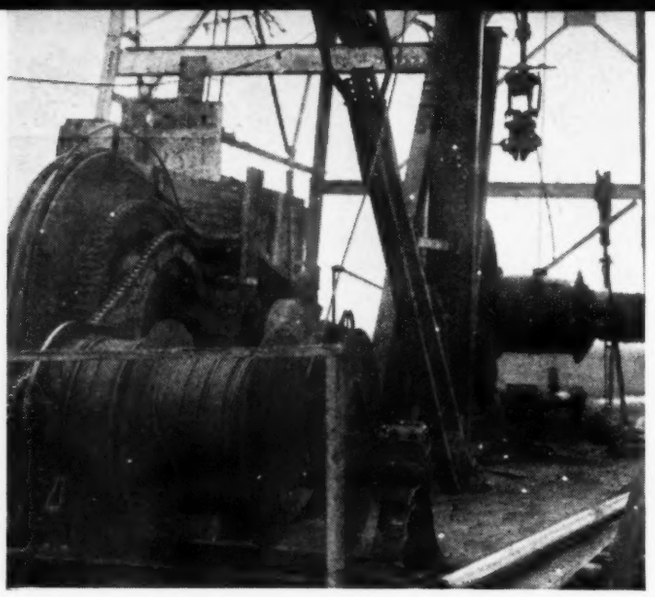

Portable Steel drilling unit used by the Olson Drilling Company in the Burrton Pool, Reno County, Kans.

Equipment and Operating Trends in Kansas Fields

By
VAN D. BENNETT
Production Engineer
Derby Oil Company

CERTAIN definite trends now are evident in surface equipment and production practices in the flush and semi-flush oil fields of Kansas. Of these, the most important concern cable tool drilling-in units, surface pumping equipment, and well servicing equipment. Although economic pressure undoubtedly has exerted considerable influence on these trends, it has also led to the adoption of modern machinery design and the application of sound engineering principles.

Conventional methods of completing and equipping pumping wells as used heretofore require little elaboration. Assuming a well had been drilled with rotary tools and the oil string cemented immediately above the producing horizon, the usual procedure required the installation of a standard wooden front, or a belt- or chain-driven steel front. This type of front was used to drill-in the well and then later to operate the well during its producing life. The average cost of these surface equipment installations was about $5000. This investment could not be appreciably adjusted in any direction regardless of whether the well had a potential capacity of 2500 bbl. per day or 100 bbl. per day. The normal production decline of these wells in two years time might bring them to 500 bbl. and 10 bbl. per day, respectively, but the high initial investment must necessarily be maintained.

In contrast with such practice consider the present procedure of some operators in Kansas deep production areas who employ the use of portable drilling-in units, individual pumping units, and pulling winches. After set-

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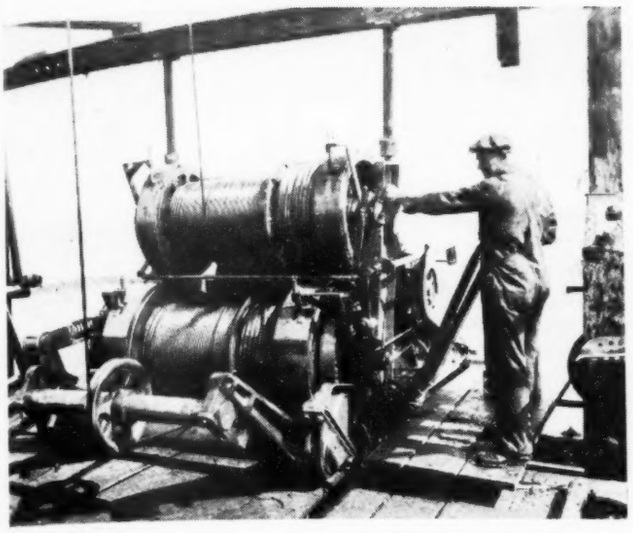


Double-drum combination drawworks, portable drilling unit, and pulling machine — in use in Western Kansas

ting the oil string on top of the producing formation with rotary tools the rotary drilling equipment is removed from the well, a portable drilling-in machine is moved in and standard tools are rigged up. While this is being done the cement is also setting. As soon as the desired depth of the pay has been penetrated and the well thoroughly cleaned out, the tubing and rods are run and a potential pumping test is taken. It is important that this potential test be obtained as soon as possible after completion of the well, because the allowable production begins only from the date the first state potential test is taken.

This potential gives the operator definite information regarding the capacity of the well to produce oil. After giving due consideration to the possibility of water encroachment, the anticipated normal oil decline of the particular producing formation and the probable characteristic subsurface conditions of the reservoir from which the well is producing, the operator usually is able to choose pumping equipment that is best suited for that particular well. Should the well be a large one the surface pumping machinery selected might be the conventional 40-hp. single cylinder gas engine, countershaft clutch, belt- or chain-driven steel front, etc. There is a trend, however, toward the use of individual pumping units, the size of the unit being determined by the capacity of the well and the estimated maximum load that the unit will be required to handle. Such individual units can be quickly installed and seldom result in the well falling behind in allowable production, for the oil operations is installed along with proper anchorage for a several days' allowable.

When the proper size pumping unit has been installed, a base plate for attaching the floor block used in well-servicing operations is installed along with proper anchorages for a pulling winch. In the event of rod or tubing jobs the pulling winch is used. It is common practice to suspend the rods in the derrick with a sucker rod hanger, thus speeding up operations, preventing the kinking of sucker rods, and eliminating the necessity of building a rodwalk.

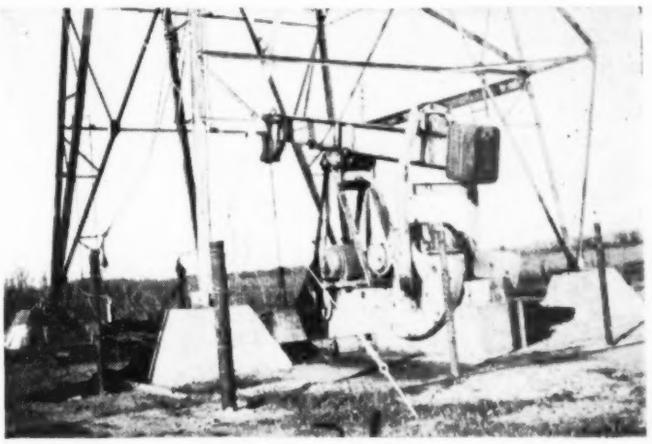
If, during the life of the well, it is desired to recondition the well or drill it deeper, the portable drilling-in unit or a pulling winch with a spudding attachment is moved into place and the operation carried out in the usual manner.

For an individual pumping unit to handle a well having a potential capacity up to 1000 bbl. per day the total material and installation cost will average about $2500. Speeding-up of moving-in operations due to the portability of equipment results in minimum lost production time and low labor costs. Efficiency in power transmission is also gained through the use of modern well-pumping machinery of this type properly installed that results in a reduction of power requirements and consequent lower fuel or electric power bills.

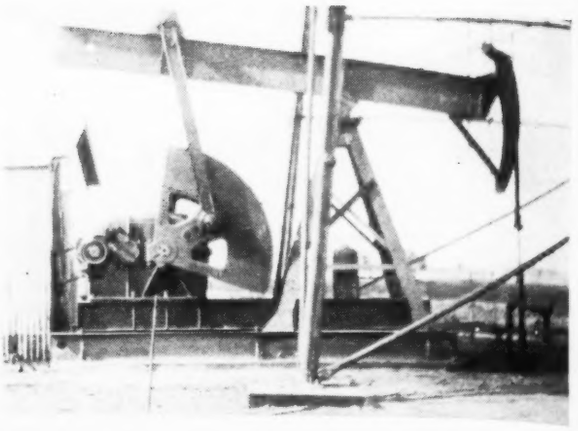
Almost all makes of portable drilling units in use in the flush and semi-flush fields of the state are chain-driven and are somewhat similar in design. The average weight of this type of unit, complete less the sand-reel, is 30,000 lb. and the steel walking beam, sampson post, pitman, and sand-reel are dismantled when the unit is to be moved. The tug-rim shaft is six in. in diameter and the unit is designed to handle any completion or reconditioning operation that would normally require a standard rig front.

Heavy portable steel drilling unit in use in Chase Pool, Rice County, Kansas

A departure from the original type of drilling-in and reconditioning units has recently been made by one company. This company has recently purchased a large double-drum combination drawworks, portable drilling unit, and pulling winch. The unit weighs 13,875 lb. complete and is powered with a 100-hp. Waukesha engine, which is fitted for operating on either gasoline or natural gas. The engine is fitted with fireproof ignition, a water-jacketed manifold, and operates at 1800 r.p.m. when developing its maximum horsepower. This



Individual pumping unit in the Hollow Pool, Harvey County, Kansas



Double-crank type pumping unit on Viola lime well in the Ritz-Canton Pool, Kansas

unit does not employ the use of a walking beam but uses a spudding attachment that is actuated by an eccentric disc on the drive shaft. Each drum has sufficient capacity for 4200 ft. of ¾-in. line and the unit has successfully drilled-in and reconditioned 3500-ft. wells with 6-in. tools, which were run in the hole on the 3500-ft. well in two minutes and withdrawn in 4½ minutes. A 5½-in. bailer can be run and pulled in a 3500-ft. dry hole in five minutes. A 26-in. or 44-in. stroke is possible with the spudding attachment and the speed may be varied within the range from 10 to 60 strokes per minute.

Another drilling-in unit used in Western Kansas on 3500-ft. wells is designed to use either a 14x14 steam engine or a 35/65-hp. variable speed electric motor. A maximum crank speed of 74 r.p.m. has been obtained while using the high side of the motor; this speed is considerably in excess of the average requirements. This unit is equipped with a 26-ft. walking beam and a 14-ft. sampson post, and is so constructed that a revolving type counterbalance may be attached for taking the pumping potential after completion of the well, a feature that is sometimes highly desirable with heavy well loads. On a recent completion operation where this unit was used, it required 40 hours to remove the rotary equipment, clean the location, and complete the rigbuilders standardization work; 24 hours were then required to set the drilling-in unit and rig up standard tools, and an additional eight hours to bail the mud to bottom and run-in with the drilling tools. Only 72 hours after the well was cemented drilling out of the cement plug was begun. For the installation of this unit $120 will cover the average labor cost.

A drilling-in unit has recently been designed for this area that incorporates the use of a hoist instead of the tugrim. This eliminates the use of bullwheels and the subsequent spooling of the drilling line, and should result in a saving of considerable investment and time. Some excellent results have also been obtained through the use of spudding attachments on the single-drum pulling winches where drilling-in or reconditioning is necessary. This practice is very economical, since it requires only an attachment to the single-drum pulling winch, and promises to gain considerable favor in the future.

There are in use in the flush and semi-flush areas of Kansas about 75 of the newer type of individual pumping units. The cost of these units ranges from $1000 to $3000 but the average installation, complete with prime mover and installed usually is less than $2500. The units incorporate the use of both gear-driven and chain-driven transmission assemblies.

Practically every make of gear-driven individual pumping unit is rep-

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Pumping unit driven by 7½-hp. electric motor on a Siliceous Lime well in the Gorham Pool, Russell County, Kansas

resented in the Kansas fields, including herringbone-, helical-, and spur-gear units of either the single- or double-reduction type; each has a preference among the various operators. The maximum polished rod load rating of the various units in use ranges from 2000 to 30,000 lb. and overall speed reduction ratios vary from 10:1 to 70.5:1. Units are equipped either with non-rotating wire line hangers or those of the straight-lift type that impart straight-line motion to the polished rod.

Both multi-cylinder engines and electric motors are used as prime movers on these units. The engines range in size from 27 to 47 hp. and are usually of the removable liner, multi-cylinder engines are preferred by some operators. Variable speed and constant speed electric motors ranging in size from 7½ to 30 hp. are in common use, and several 9/16/25-hp. and 10/20/30-hp. triple-rated motors are in operation.

Several chain-driven individual pumping units have been installed and have been giving excellent results. One unit of this type has a 6-in. crank shaft and is fitted with a standard

Pumping unit driven by multi-cylinder engine on well north of Galva, Kansas

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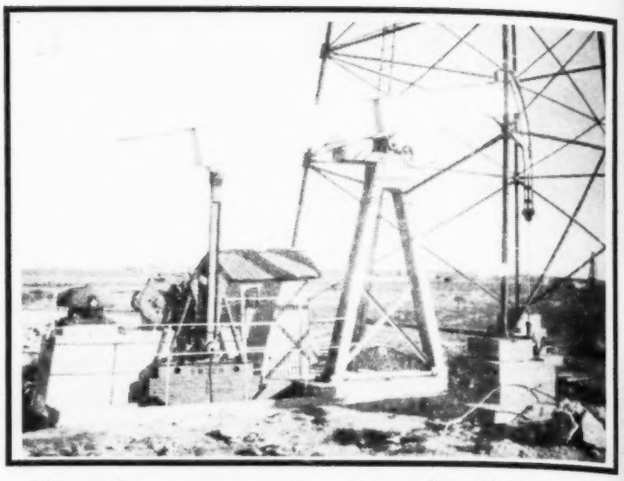

Herringbone gear pumping unit on Oswald Lime well, Russell County, Kansas

A.P.I. crank and counterbalance. It is a double-reduction unit, the first reduction being made through a quadruple Diamond roller chain of 1-in. pitch and the second through a triple Diamond roller chain of 2-in. pitch.

A geared unit with a 10-ft. stroke has been in operation for some time in Marion County, Kansas, and is lifting about 1640 bbl. of fluid per day, 97 per cent of which is water, from 2400 feet. The well is equipped with 3-in. tubing and operates at a speed of seventeen 10-ft. strokes per minute, and is powered with a 40-hp. electric motor.

A twin-crank, double-reduction, helical gear unit, rated at 20-hp. at 20 r.p.m., installed on a Siliceous Lime well in Russell Co., Kansas, recently lifted 1400 bbl. of oil from 3400 ft. in 24 hours on a state potential test. This particular type of unit has been run as fast as 35 s.p.m. on wells 3400 ft. deep on maximum production tests.

Under average conditions, about 12 cu. yards of concrete are used in setting these units and the total installation cost for material and labor will be approximately $350 per unit.

When a pumping well is equipped with an individual pumping unit it is of course necessary to handle rod and tubing jobs with a pulling winch; even for servicing wells that are equipped with conventional pumping fronts and 40-hp. engines or 15/30-hp. electric motors, some operators use a pulling winch almost exclusively, because of the reduced time needed to service a well, and the resultant saving in labor costs. On motor-driven pumping wells the demand charge can be reduced to the pumping peak demand. This sometimes results in a reduction of $10 or more per well per month. On wells equipped with single cylinder gas engines, experience shows that 90 per cent of the clutch repairs have been eliminated, wear and tear on the engines from overspeeding when pulling rods and tubing are materially reduced, and, dismantling and replacing the counterbalance being unnecessary, a further saving in time and labor is gained.

A string of $\frac{7}{8}$-in. sucker rods have been pulled from a 3400-ft. well at a rate of 250 rod ft. per minute, and $2\frac{1}{2}$-in. tubing at an average speed of 100 tubing ft. per minute. A rod and tubing job can be speeded up as much as 40 per cent by the use of a pulling winch, a very significant factor when the six-hour labor day is considered, for it allows jobs to be completed and the wells put back on production on the same day. A pulling winch of the type most widely used in the deeper Kansas areas weighs 4750 lb. and can easily be transported on a $1\frac{1}{2}$-ton truck. There are about 300 pulling winches in use in Kansas today, at least 125 of which are used in the flush and semi-flush deep production areas.

Recognition of the advantages, both economic and mechanical, involved in the use of this newer type of equipment is responsible for its wide adoption by Kansas operators.

Plants of a Few of Kansas' Foremost Manufacturers of Oil Field Equipment

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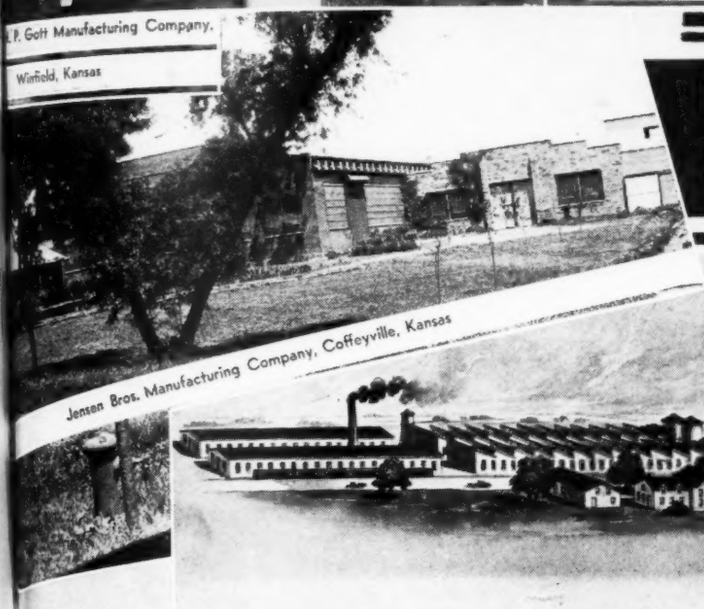
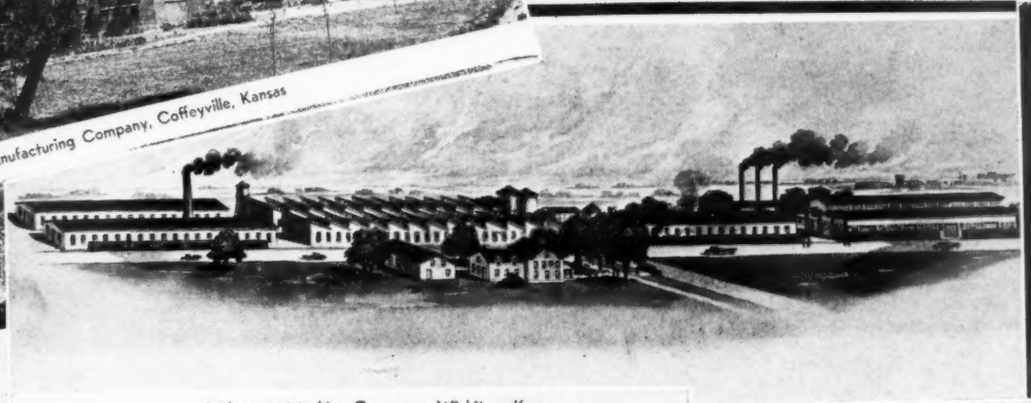


Jensen Bros. Manufacturing Company, Coffeyville, Kansas



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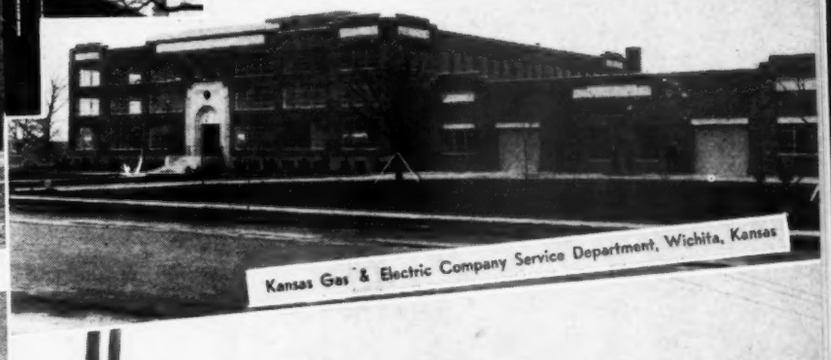

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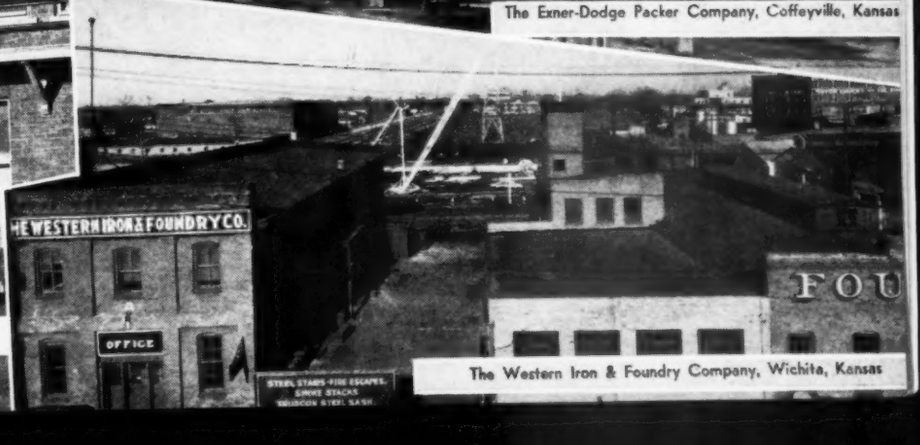

The Western Iron & Foundry Company, Wichita, Kansas

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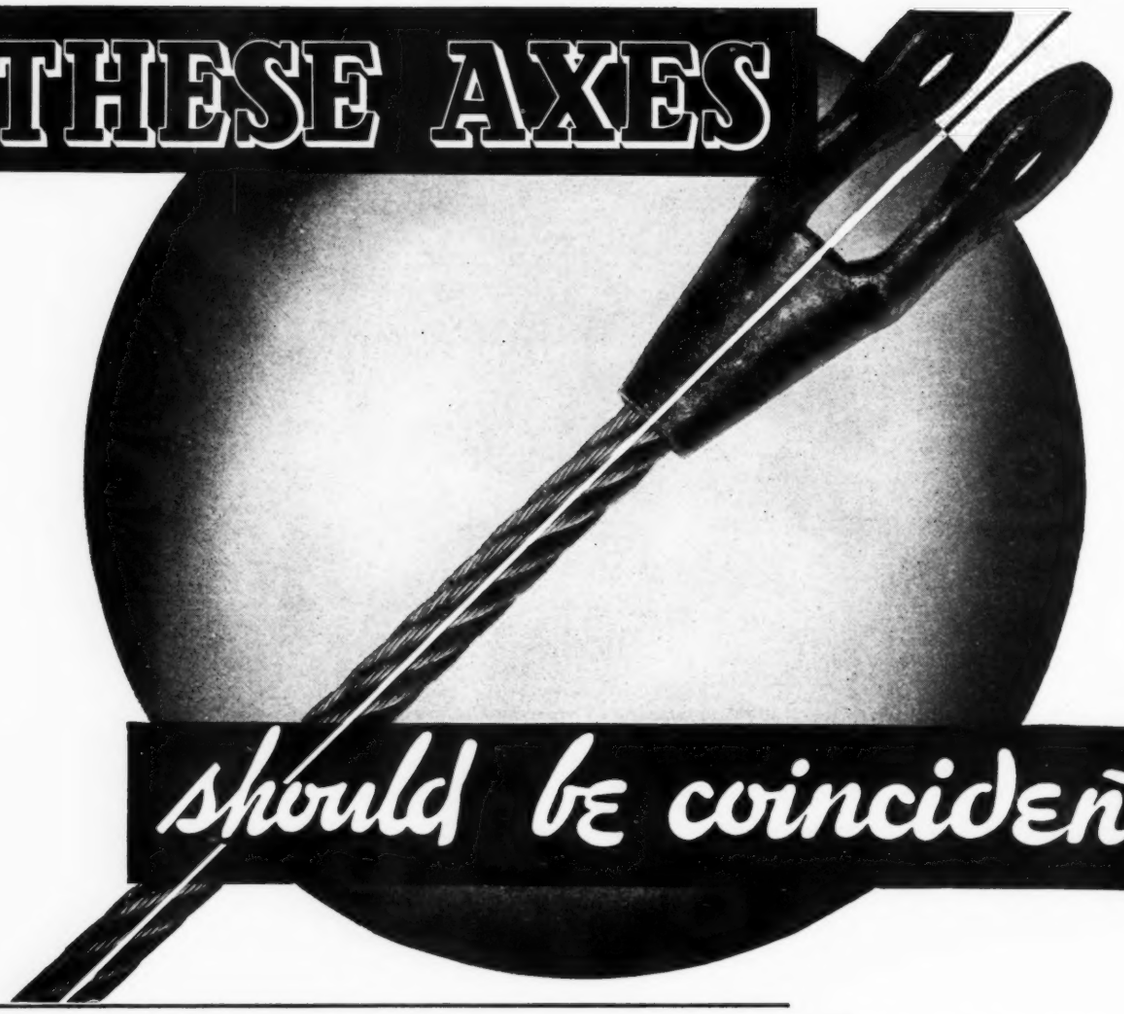

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Editors

Elements of Applied Petroleum Production

Article 14

EQUIPMENT AND OPERATION OF OIL WELLS (Continued)

By K. C. SCLATER

FLOWING WELLS—Continued

PRIME MOVERS. Power in some form is necessary to operate an oil well pump. There are a variety of types of prime movers used for this purpose. They include:

Steam engines
Gas engines
Oil engines
Gasoline engines
Diesel engines
Electric motors
Hydraulic cylinders
Pneumatic cylinders

Reciprocating steam engines of the horizontal type were at one time widely used for well-pumping. They are now relatively unimportant as a prime mover in modern well-pumping operations because of their low thermal efficiency and the added cost required for upkeep of steam-raising equipment.

Gas engines used for pumping wells include those of the horizontal, slow-speed, single-cylinder type and also those of the vertical, high-speed, multi-cylinder type. The former, both the 2-cycle and 4-cycle, are especially well adapted for oilfield service. They operate on natural gas. More gas engines are employed in well-pumping operations than any other type of prime mover.

Where the well is pumped on the beam with a standard rig the engine is also used for pulling tubing and rods, and for cleaning-out. For this service, horizontal single-cylinder, 2-cycle or 4-cycle, slow-speed, heavy-duty gas engines are employed. They may be of any desired horsepower to suit the well's requirements. One of the most generally used is the 40-hp. single-cylinder, slow-speed engine. There are several other reasons besides those mentioned for this general use. Natural gas is available in many oilfields at little or no cost. The average well-pumping speed has always been from 20 to 30 strokes per minute; with belt transmission of the standard rig limited to an eight to one ratio, an engine speed of 150 to 200 r.p.m. was automatically adopted.

The vertical, multi-cylinder type of engine is increasing in use in modern well-pumping practice as a result of the improved types of power transmissions that have been developed.

Most of the oil engines used for pumping wells are of the horizontal slow-speed type. Like the gas engine, they may be used for pulling rods and tubing and for cleaning-out.

Gasoline engines employed for oilwell pumping are of the multi-cylinder, high-speed type and are employed in localities where the supply of natural gas is scarce or absent. Usually they are equipped for using natural gas fuel if necessary.

Multi-cylinder, high-speed Diesel engines are now used for well-pumping. Where natural gas has to be purchased for fuel, a Diesel engine prime mover may, on low oil fuel consumption alone, be favored for economical operation.

Internal combustion engines as a whole are well adapted for oilfield service. Besides fuel and lubricating oil, their only other requirements are clean circulating water and reasonable care.

Electric motors[65] of the oil-well, squirrel cage, Y Delta or Y Delta Delta, type are used for oil well pumping. Ledeen[66] in discussing prime movers for well-pumping states that, "Where electric power is cheap, one cent per kw-hr. or less, and the horsepower requirements are low, five hp. or less, the electric motor seems to be the most desirable selection.

Where power rates are high, natural gas available at little or no cost, and the horsepower required heavy, the slow-speed natural gas engine meets with a great deal of favor.

There are a number of shadow ranges, however, where the selection depends on individual figures and preferences, where the final balance is struck between price of equipment, cost of repairs, maintenance, depreciation, power bills and other

items usually taken into account. . . . Within certain limitations higher efficiencies and higher power factors are obtained from motors operating on the higher speeds. The same factors are, likewise, affected by the rating of the motor. The higher the ratio of the power used to the power rating, the greater will be the efficiency and power factor, and the lower the first cost.

An actual load of four hp. may be delivered by an electric motor of five hp. rating, or by one of 25 hp. rating. The ratio will be 80 per cent on the 5-hp., and 16 per cent on the 25-hp. motor. If a 25-hp. motor is used, there will be a large reserve capacity for other operations that may be necessary. This reserve will be paid for by lower power factor, lower efficiency and higher initial investment.

If the motor to be used will be called upon not only to pump the well, but to operate the hoist, sand reel, bull-wheel and other equipment, certain compromises will be necessary in speed, size and operating characteristics. The oil well motor is usually the selection for such work. Where, however, auxiliary operations can be performed by portable pulling equipment, and where the load on the well will be fairly stable, an ordinary squirrel cage electric motor can be used, which will give the highest possible power factor and efficiency, and the least possible first cost.

Where some compromise can be made between these two extremes, the Y Delta motor or its successor, the Y Delta Delta motor, finds a useful application; with their double or triple power ratings, all at the same speed, it is possible to select a good operating speed (1200 or 1800 r.p.m.) and to operate a well at or near one of the two or three ratings that gives a good power factor and efficiency. By switching from one rating to another, it is possible to operate the hoist within certain limits."

An interesting application of the electric motor as a prime mover in well-pumping is its employment in the Reda electric pump, a pumping unit the design of which is such that no sucker rods are necessary. The motor is lowered into the well along with the pump.[67]

Prime movers of the hydraulic or penumatic cylinder type are confined to special types of oil-well pumping units. The hydraulic jack pumping unit is an example of the former, and the Sullivan pneumatic head[58, 68] an example of the latter.

POWER TRANSMISSION. Power must be transmitted from the prime mover to the polished rod. The necessity, purpose, and importance of power transmission systems on pumping wells are clearly expressed in the following statement:[69]

"Since the operating speed of the pumps must range from one to thirty strokes per minute, and the best operating range of internal combustion engines lies between 200 and 600 r.p.m., and of electric motors between 600 and 1800 r.p.m., it becomes necessary to introduce some sort of transmission between the prime mover and the pump—a transmission that will reduce the necessarily high prime mover speed to the desirable low pump speed.

"The transmission, like the motor and the pump, must be economical, not wasteful; or the profit in wise selection of pump and motor may be offset by losses in the transmission itself.

"This transmission must not only change the speed, but it must transmit it smoothly, and must deliver it without superimposing upon either prime mover or pump any internally generated shocks or jerks.

"The pump itself, due to its reciprocating nature, is bound to have fluctuating load requirements. At the beginning of the cycle a large amount of power is required to accelerate the rods and oil. Toward the end of the cycle the acceleration has all taken place and little power is required. Numerous indicator cards show that the power demand has an exceedingly wide range between minimum and maximum during the pumping cycle.

"As efficient operation cannot be expected from either an electric motor or an internal combusion engine under such fluctuating demands, it becomes desirable to introduce between the prime mover and the pump some energy-absorbing system, either a stabilizer, a flywheel or gyroscope that will take up the power from the engine or motor at the instant that it is generated, absorb it, and store it up as to redeliver it to the pump at the instant that it is required. This stabilizer element usually takes the form of a counterbalance, mounted on the beam, pitman, or crank."

Power transmissions in use in well-pumping follow a variety of designs. They include belt transmissions, chain transmissions, and gear transmissions.

The belt transmission on wells pumped individually on the beam by standard rig, used between the engine and bandwheel, is one of the best known and most widely used. If the engine is used for pulling rods and tubing, a reversible clutch is used in the transmission, and many of the wells are so equipped.

The insistent demand for greater economy of operation has brought about many refinements in the design and construction of surface equipment for well-pumping service. Thus many of the individual pumping units now are of the geared type and incorporate part of the power transmission system in the pumping unit itself.

QUESTIONS

1. Give some of the reasons for the wide use of the horizontal, slow-speed, type of gas engine for well-pumping service.
2. What are the factors that favor the use of electric motors as prime movers for pumping wells individually?
   That favor the use of gas engines?

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[68] "Pneumatic Unit for Individual Well-Pumping," by K. C. Sclater—*The Petroleum Engineer*, p. 25, February, 1934.

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Elements of Applied Petroleum Pipe Line Transportation

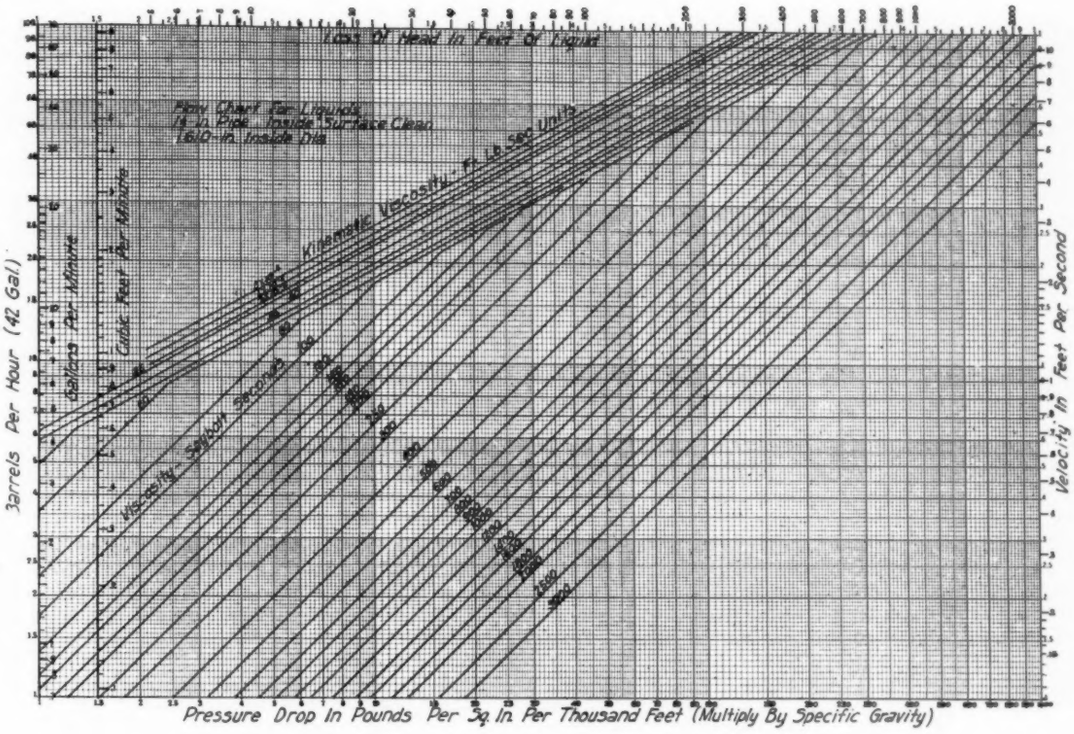
Article 5

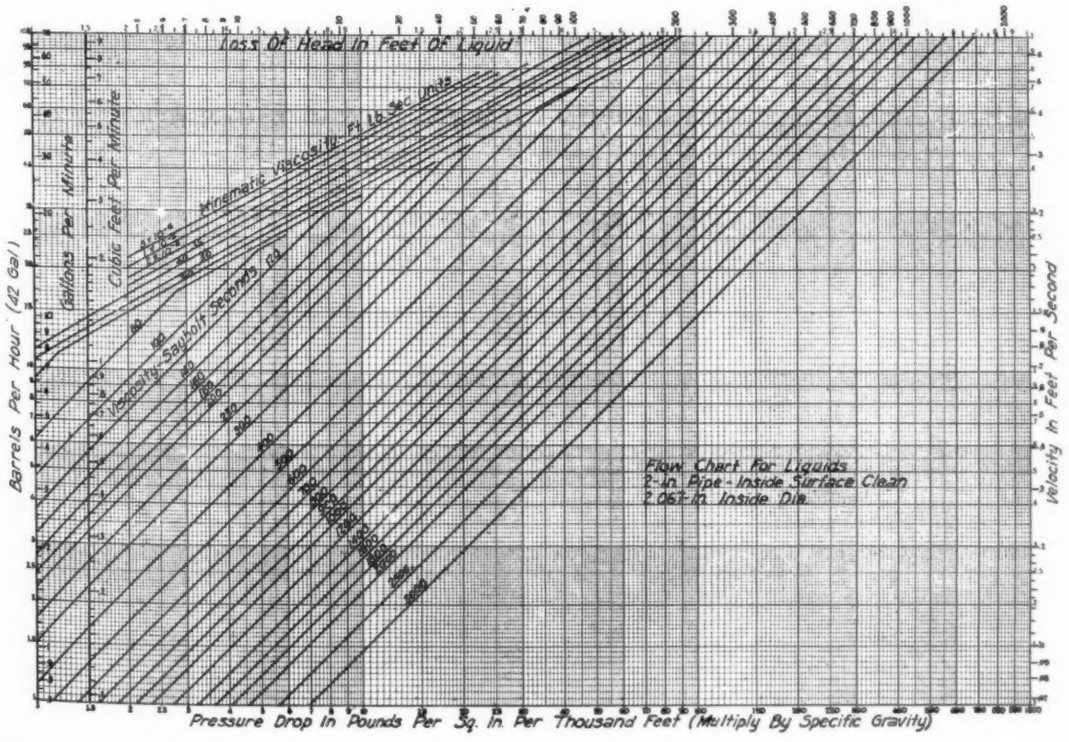
THE FLOW OF OIL IN PIPES AND PIPE LINES

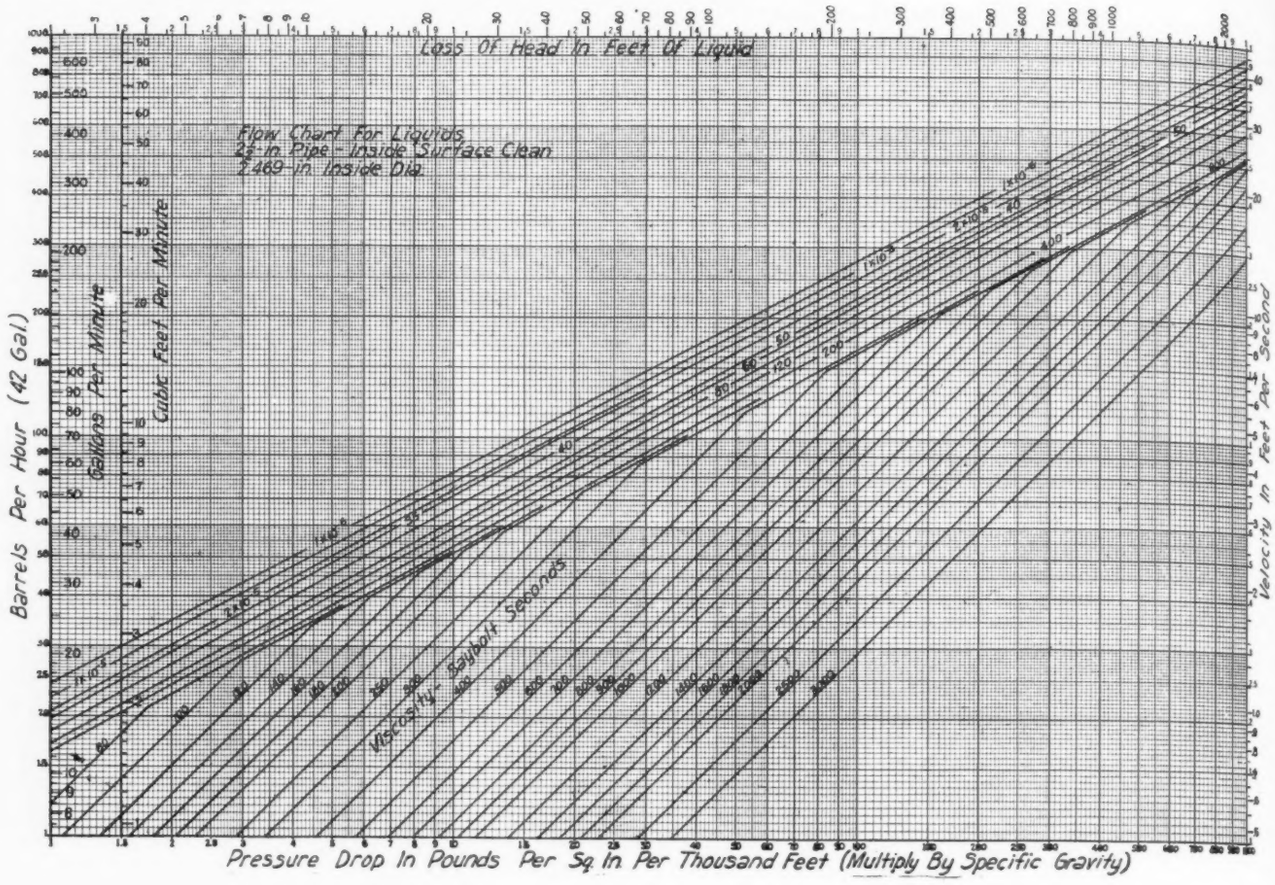
Part 5—Charts for Parallel Lines

By EMORY KEMLER
and L. L. THOMAS

FOUR more charts for the solution of flow problems in pipes and pipe lines are given this month. They are for 1½-in. pipe, 2-in. pipe, 2½-in. pipe, and 3-in. pipe, respectively.


Loss Of Head In Feet Of Liquid
Flow Chart For Liquids
1½-In. Pipe - Inside Surface Clean
1.610-In. Inside Dia
Kinematic Viscosity - Ft. Lb. sec. Units
Viscosity - Saybolt Seconds
Barrels Per Hour (42 Gal)
Gallons Per Minute
Cubic Feet Per Minute
Velocity In Feet Per Second
Pressure Drop In Pounds Per Sq. In. Per Thousand Feet (Multiply By Specific Gravity)


Loss Of Head In Feet Of Liquid
Kinematic Viscosity - Ft Lb Sec. Units
Viscosity - Saybolt Seconds Universal
Barrels Per Hour (42 Gal)
Gallons Per Minute
Cubic Feet Per Minute
Velocity In Feet Per Second
Flow Chart For Liquids
2-In. Pipe - Inside Surface Clean
2.067-In. Inside Dia
Pressure Drop In Pounds Per Sq. In. Per Thousand Feet (Multiply By Specific Gravity)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2.469-in. Inside Dia.
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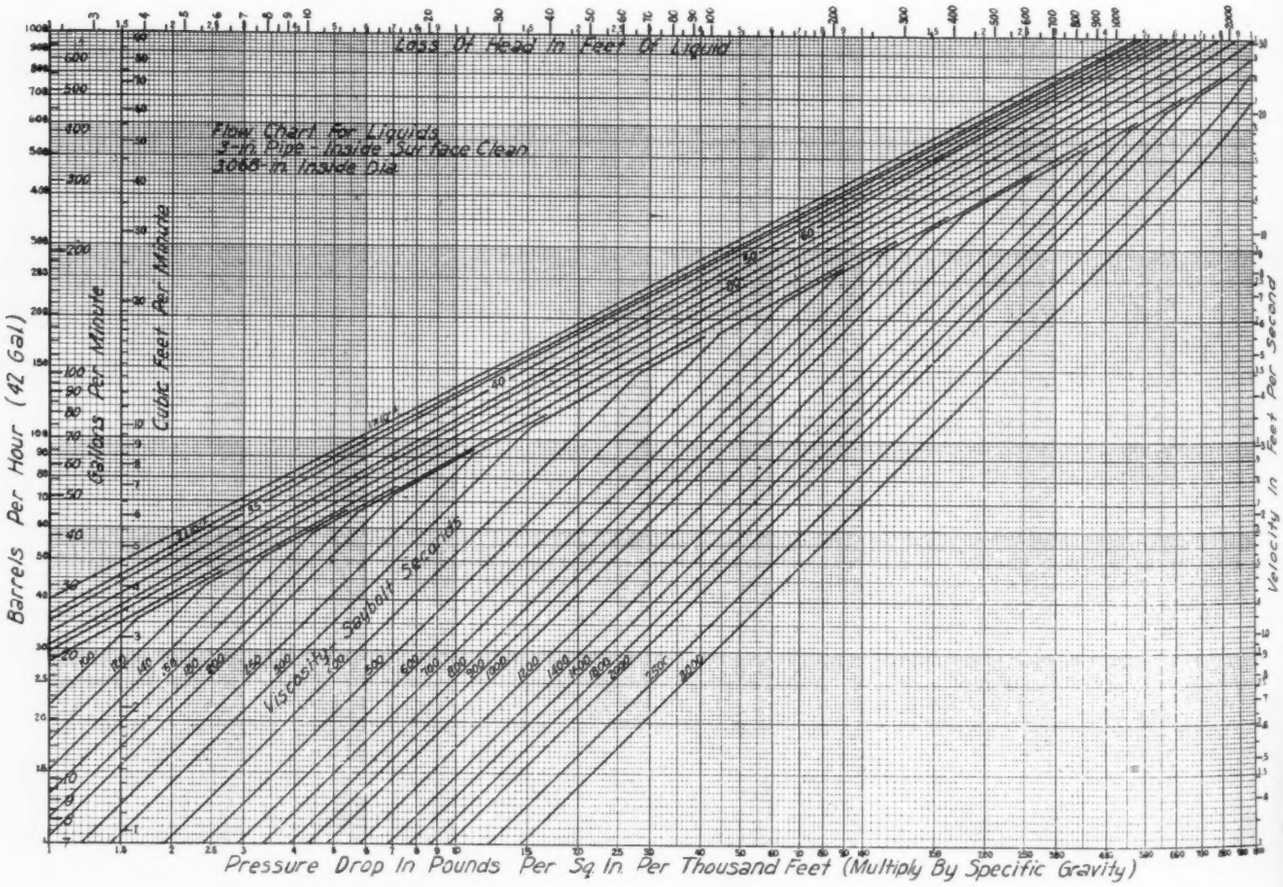
Gallons Per Minute
Cubic Feet Per Minute
Velocity In Feet Per Second
Viscosity - Saybolt Seconds
Pressure Drop In Pounds Per Sq In. Per Thousand Feet (Multiply By Specific Gravity)


Loss Of Head In Feet Of Liquid
Flow Chart For Liquids
3-in. Pipe - Inside Surface Clean
3.068-in. Inside Dia.
Barrels Per Hour (42 Gal)
Gallons Per Minute
Cubic Feet Per Minute
Velocity In Feet Per Second
Viscosity - Saybolt Seconds
Pressure Drop In Pounds Per Sq In. Per Thousand Feet (Multiply By Specific Gravity)

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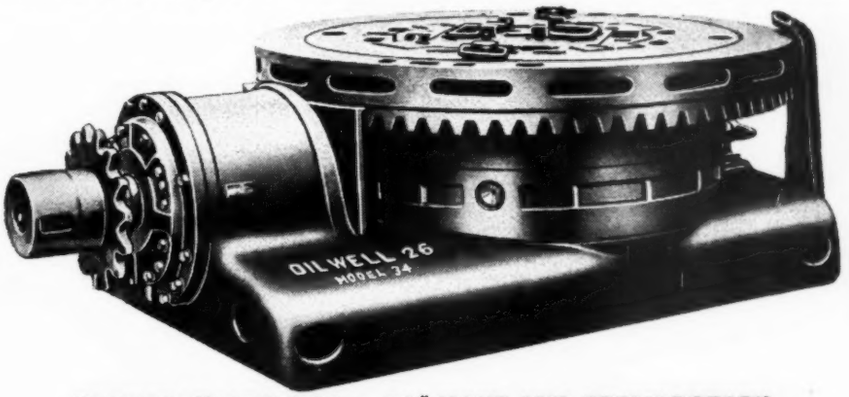

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Elements of Applied Petroleum Refining

By W. L. NELSON
Consultant*

Article XIV

PHYSICAL PROPERTIES OF FRACTIONS OF PETROLEUM OIL

THE computation of the volume of liquid and gaseous petroleum products at different temperatures constitutes a vital part of any plant study or design. The volume can be accurately computed, unless the material is at or near the critical condition. In other words, if the temperature or the pressure is very high the volume cannot be exactly computed.

CRITICAL CONDITIONS

If a pure liquid is heated it will eventually attain its boiling-point and will be vaporized if the heating is continued. However, if the pressure is raised the vapor will be condensed and the resulting liquid must be heated to a higher temperature before it will boil. Thus, the boiling point increases as the pressure is increased. The material behaves in this manner until the critical point is reached. At the critical point the vapor cannot be condensed regardless of how much the pressure is raised. As an example, water can be heated to 706 deg. fahr. by raising the pressure to 3200 lb. per sq. in. but at 707 deg. fahr. no amount of pressure will cause the water vapor to condense. Thus, the critical point involves two factors, the critical pressure (3200 lb.) and the critical temperature (706 degrees).

The condition of the material above the critical point should hardly be classed as liquid or vapor. If it is a vapor it is a very dense one and cannot be compared with the gases and vapors with which we are familiar. If it is a liquid it is a very light and fluid one. In fact the density of the liquid that is just below the critical point has the same density (lb. per unit vol.) as the vapor that is just above the critical point. The relation of the density and temperature for water at the critical pressure is indicated by Fig. 31. Temperature is plotted along the base axis and specific volume along the vertical axis. Specific volume is the volume in cu. ft. that one pound of material occupies. It is the inverse of density; that is, the density is equal to one divided by the specific volume.

$$\text{Density} = \frac{\text{lb.}}{\text{cu. ft.}} = \frac{1}{\frac{\text{cu. ft.}}{\text{lb.}}} = \frac{1}{\text{specific volume}}$$

$$\text{Specific Volume} = \frac{\text{cu. ft.}}{\text{lb.}}$$

Fig. 31 shows that the specific volume of liquid water increases slowly as the temperature is increased. However, at the critical temperature the volume increases rapidly and then in the vapor state it again increases at a somewhat uniform rate. The gas tends to approach the line for perfect gases but no gases behave perfectly at or near the critical point.

*Professor of Petroleum Refining, University of Tulsa.

Petroleum hydrocarbons and mixtures behave in much the same way as water except that the critical temperatures are lower and the critical pressures are much lower. The critical temperatures and pressures[1] of some hydrocarbons are shown in Table 12.

The absolute temperature deg. fahr. that is used in Table 12 refers to the temperature above absolute zero. Since absolute zero is minus 460 deg. fahr., the absolute temperature is equal to deg. fahr. plus 460.

$$\text{Deg. fahr. Abs.} = \text{Deg. fahr.} + 460$$

Likewise, the absolute pressure is the pressure above a perfect vacuum. Since the standard atmospheric pressure is 14.7 lb. per sq. in. the absolute pressure is:

$$\text{Abs. pressure} = \text{gauge pressure} + 14.7$$

The critical temperature of commercial products is somewhat different because these materials are mixtures. Table 13 indicates the critical temperatures and approximate critical pressures of commercial products.

Table 13 indicates that many of the temperatures used in the refinery in common operations are higher than the critical temperatures of the materials being handled. Thus, in topping crude oil the pipestill outlet temperature is frequently 670 deg. fahr., and this is higher than the critical temperature of gasoline and kerosene. However, the whole crude oil is heated together in the pipestill tubes and hence, probably most of the gasoline is not vaporized.

TABLE 12

Material—	Critical Temperatures Deg. fahr. Abs.	Deg. fahr.	Critical Pressure Lb./sq. in. Abs.	Critical Volume Cu. ft./lb. mol.
Methane . . .	344	—116	673	1.59
Ethane . . .	550	90	709	2.19
Propane . . .	664	204	632	3.04*
Butane . . .	767	307	529	4.00*
Pentane . . .	847	387	485	4.97
Hexane . . .	914	454	435	5.88
Heptane . . .	972	512	396	6.85
Octane . . .	1025	565	362	7.86

*Interpolated values.

TABLE 13
CRITICAL CONDITIONS FOR PRODUCTS

Material—	A.P.I.	Critical Conditions Temp. deg. fahr	Pressure Lb. /sq. in.*
Petroleum Ether . . .	81	412	450
Gasoline	54-61	570-590	360
Kerosene	41-45	709-765	210
Gas Oil	28-38	847-892	150

*Estimated.

Example 8—Absolute Temperatures and Pressures:

An oil is to be heated to 500 deg. fahr. at a pressure of 30 lb. per sq. in. gauge. What is the absolute temperature and pressure?

The absolute temperature is:

$500 + 460 = 960$ deg. fahr. abs. (sometimes called deg. Rankin).

The absolute pressure is:

$30 + 14.7 = 44.7$ lb. per sq. in. absolute.

Many of the physical properties of liquids change rapidly at or near the critical point. As an example, the heat of vaporization decreases as the boiling-point is increased until at the critical point it is zero. The surface tension behaves in a similar manner and at the critical point the liquid has no surface tension. In other words, there is no partition between the liquid and vapor phase at the critical point, and in fact, the two phases cannot exist together. Even solids are about as soluble in the vapor as in the liquid, at the critical point. This is illustrated by experiments with high-pressure boilers in which the solid material in the feed water distilled with the water and accumulated in the condensers.

EXPANSION OF LIQUIDS

The rate at which oils expand upon heating is usually described by the coefficient of expansion. The coefficient of expansion may be defined as the fractional increase in volume that occurs when a material is heated through a temperature range of one degree. Thus, if the coefficient of expansion is 0.001 the material will increase in volume by 0.1 of one per cent for each degree that the material is heated.

The coefficient of expansion for petroleum oils are usually given as follows:

Gravity Range	*Mean Coefficient of Expansion*
79 and lighter	0.0008
78.9-65	0.0007
64.9-51	0.0006
50.9-35	0.0005
34.9-15	0.0004
14.9-0	0.00036

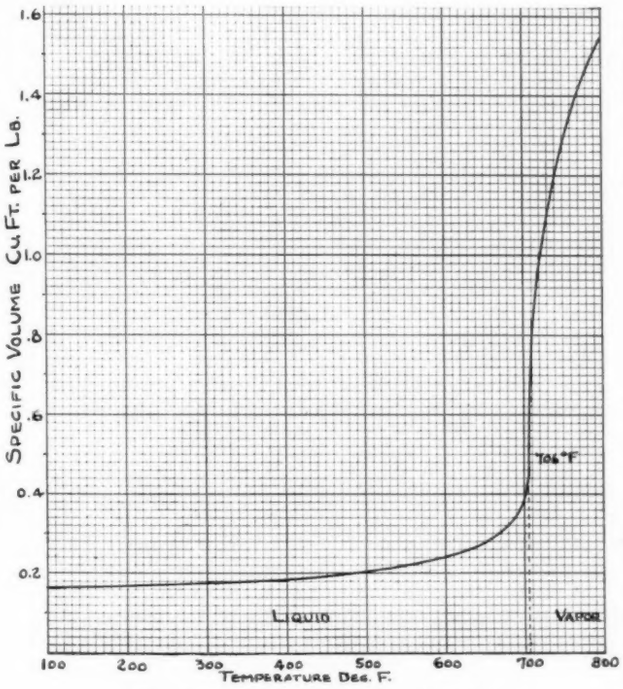

Fig. 31. Specific volume of water

These coefficients should not be used at temperatures exceeding about 400 deg. fahr., and for higher temperatures Fig. 32 should be used. The volume of oil in storage tanks is computed in the refinery each day by means of these coefficients.

Example 9—Volume of Oil in Storage Tanks.

By tank gauge, a tank contains 1921.1 bbl. of oil as 78 deg. fahrenheit. The A.P.I. gravity at 60 deg. fahr. is 43. What is the volume of this oil at 60 deg. fahrenheit?

The coefficient of expansion for a 43 A.P.I. oil is 0.0005. The oil would be cooled through 18 deg. in cooling to 60 deg. fahrenheit.

Shrinkage: $0.0005 \times 18 \times 1921.1 = 17.29$ bbl.

The volume at 60 deg. fahr. is $1921.1 - 17.29 =$ 1903.8 bbl.

Plant inventories are normally taken at 60 deg. fahrenheit.

CHANGE OF GRAVITY WITH TEMPERATURE. Specific gravity likewise changes with temperature. The effect of temperature is shown in Fig. 32. The gravity that is marked on the lines, is the specific gravity at 60 deg. fahrenheit. The specific gravity at other temperatures may be found on the vertical axis. The curves of the different materials are almost straight until the critical temperature is approached and then they curve downward sharply. The curves are not entirely exact at high temperatures but they are more exact, barring inaccuracies in reading the curves, than the coefficients that are tabulated herein.

The relation of specific gravity to the A.P.I. gravity is as follows:

$$\text{A.P.I.} = \frac{141.5}{\text{Sp. Gr.}} - 131.5$$

Example 10—Specific Gravity at High Temperature.

1000 gal. per hr. of pressure distillate (57.3 A.P.I.) is to be heated to 300 deg. fahr. in a pipestill. What is the specific gravity at 300 deg., and how many gallons of hot oil pass through the tubes per hour?

The specific gravity of the distillate at 60 deg. is:

$$57.3 = \frac{141.5}{\text{Sp. Gr.}} - 131.5$$

Specific gravity $= 0.75$ at 60 deg. fahr.

From Fig. 32: Specific gravity at 300 deg. $= 0.648$.

The volume of the distillate increases inversely proportional to the change in specific gravity.

Volume of distillate at 300 deg. $= 1000 \times \frac{.75}{.648} = 1157$ gal. per hour.

Molecular Weight and Pound Mol

Molecular weight is a physical property that is useful in computing the volume of gases and hence it will be presented at this point. When materials react together chemically the molecules of one material combine or act upon the molecules of the other material. Hence, the weights of material that react together are simple multiples of the weights of the molecules. This accounts for the wide usefulness of molecular weights in physical and chemical calculations.

The molecular weight can be obtained from the chemical formula of the substance by totaling the weights of the atoms that compose the molecule. The weights of the atoms (atomic weight) can be found in any elementary chemistry text. Thus, the formula of methane is CH_4; that is, methane consists of one atom of carbon (weight 12) and four atoms of hydrogen (weight 1.008) and the molecular weight is 16.032. The weight of an oil or gas is frequently expressed as pound or gram mols (molecules). The pound mol is defined as a molecular weight worth of material expressed in pounds. Thus, a pound mol of methane is 16 pounds of methane and a mol of carbon is 12 pounds of carbon.

The average or apparent molecular weight of a mixture can be computed by dividing the total number of pounds of material by the number of mols. See Example 11.

Likewise, the mol percentage can be computed by divid-

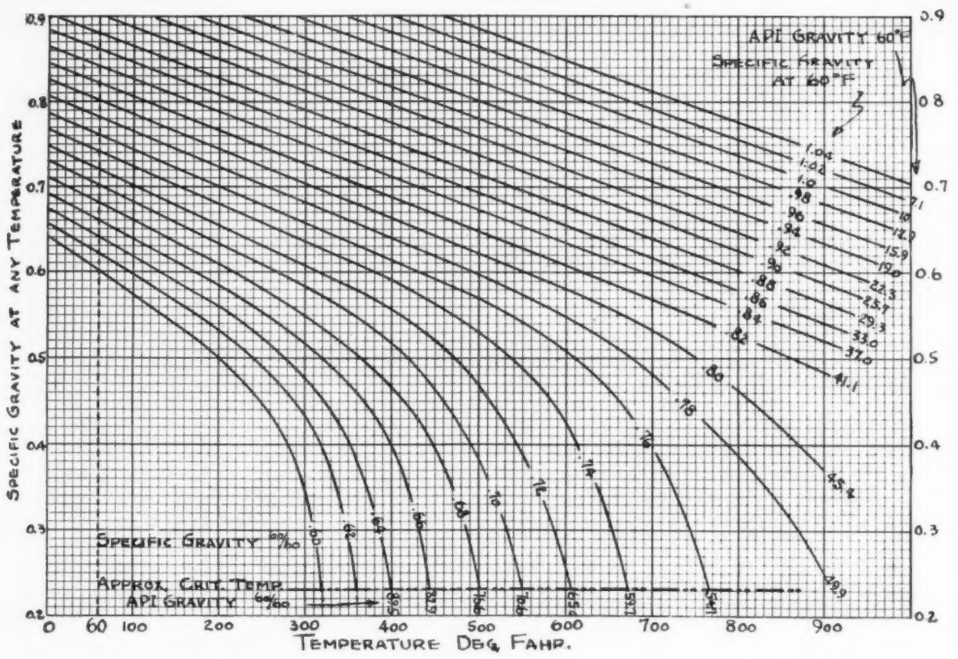

Fig. 32. Change of specific gravity of oils with temperature

ing the mols of each constituent by the total number of mols. See Example 12.

Example 11—Apparent Molecular Weight.

The analysis of a natural gas expressed as mol percentage, is as follows:

CH_4	88 (methane)	C_4H_{10}	2.4 ((butane)
C_2H_6	5 (ethane)	C_5H_{12}	1.6 (pentane)
C_3H_8	3 (propane)		

What is the average or apparent molecular weight?

Basis: One pound mol of gas

(1)	(2) Mol Percentage	(3) Mols (2) ÷ 100	(4) Mol Wt.	(5) Wt. lb. (3) × (4)
CH_4	88	0.88	16	14.08
C_2H_6	5	0.05	30	1.50
C_3H_8	3	0.03	44	1.32
C_4H_{10}	2.4	0.024	58	1.39
C_5H_{12}	1.6	0.016	72	1.15
	100.0	1.000		19.44

$$\text{Mol Wt.} = \frac{\text{pounds}}{\text{mols}} = \frac{19.44}{1} = 19.44$$

Example 12—Molecular Weight of Oil.

A 59 A.P.I. gasoline has a boiling range of 120 to 410 deg. fahrenheit. The 50 per cent boiling-point is 245 deg. fahrenheit. What is the molecular weight and how many mols are being handled when 1000 bbl. of gasoline are produced per day?

Molecular Weight: The molecular weight can be read directly from Fig. 33.

Molecular weight is 105.

Mols of gasoline:

Gal. gaso. per hour =

$$1000 \times \frac{42}{24} = 1750$$

Weight per gallon:

$$\text{A.P.I.} = \frac{141.5}{\text{Sp. Gr.}} - 131.5$$

$$59 = \frac{141.5}{\text{Sp. Gr.}} - 131.5$$

$$\text{Sp. Gr.} = 0.743$$

The weight of one gallon of water is 8.33 pounds.

Weight per gal. =

$$0.743 \times 8.33 = 6.185$$

Mols gaso. per hour =

$$\frac{1750 \times 6.185}{105} = 103$$

Although the molecular weight of petroleum oils varies greatly because of differences in boiling-range, gravity, etc., the following tabulation is useful for approximations and comparisons:

Material	*Molecular Weight*
Gasoline	100-120
Kerosene	185-200
Gas Oil	210-240
100 Viscosity Neutral	300-360
400 Viscosity Neutral	370-470

Example 13—Mol Percentage.

A coke has the following analysis by weight:

C	95	(carbon)	S	0.3	(sulphur)
H_2	3.6	(hydrogen)	H_2O	1.1	(water)

Compute the percentage on a mol basis.

The mol percentage is shown in column (6). (See Table 14.)

The apparent molecular weight of coke is of little significance, but it can be computed as an illustration.

$$\text{Apparent mol wt.} = \frac{100}{9.787} = 10.21$$

The molecular weight of petroleum oils cannot be computed in this manner because an analysis of the oil that shows

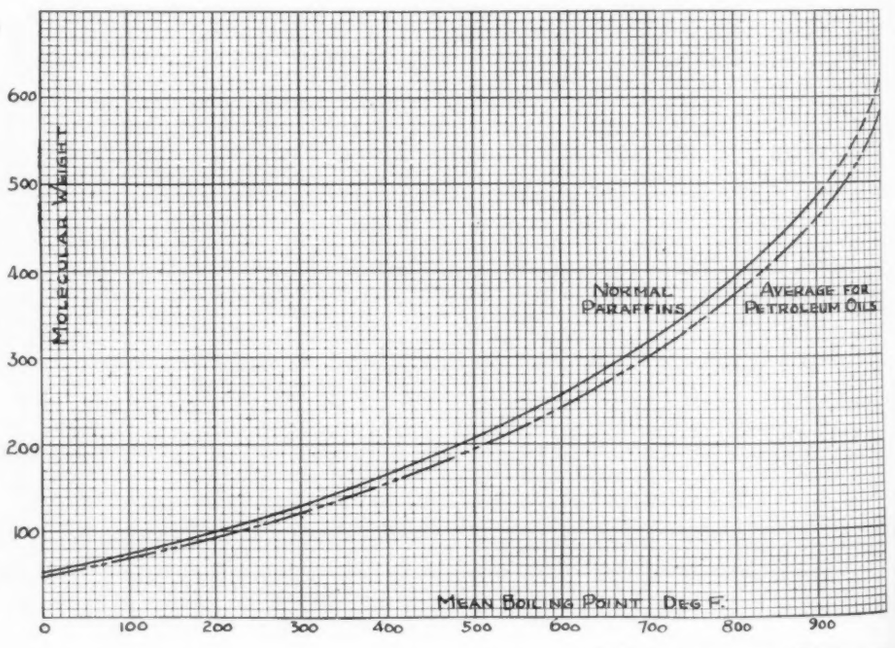

Fig. 33. Molecular weight of petroleum oils

the compounds that are present, is seldom available. The molecular weight of oils is usually tabulated against boiling-point or specific gravity. Fig. 33 shows the molecular weights of the normal paraffin hydrocarbons plotted against boiling-point and also an average line for petroleum oils.

Table 14

Basis: 100 lb. of coke

(1)	(2) Lb.	(3) Mol Wt.	(4) Mols (2)÷(3)	(5) Mol Frac. (4)÷9.787	(6) Percentage (5)×100
C	95	12	7.917	.8090	80.9
H_2	3.6	2	1.800	.1839	18.39
S	0.3	32	.009	.0009	.09
H_{20}	1.1	18	.061	.0062	.62
			9.787	1.0000	100.00

MOL VOLUME OF GASES. Equal volumes of gases contain the same number of molecules and hence there is a definite relation between the volume of any gas and the number of mols that it contains. If the gas is measured at 60 deg. fahr., a pound mol of the gas will occupy 379 cu. feet. Thus, 16 lb. of methane occupies 379 cu. ft. at 60 deg. fahr. and 14.7 lb. per sq. in. pressure. Likewise, two lb. of hydrogen, 44 lb. of carbon dioxide, 32 lb. of oxygen, 28 of nitrogen and 28 of carbon monoxide, each occupy 379 cu. feet.

For the same reason the mol percentage and the volume percentage of a gas are numerically the same.

Example 14—Volume of Gas from Weight.

Air contains 79.1 per cent of nitrogen and 20.9 per cent of oxygen by volume. What is the volume (60 deg. fahr. atmos. press.) of 100 lb. of air?

The average molecular weight of air is:

$.209 \times 32 = 6.7$

$.791 \times 28 = 22.15$

Av. M. W. $= 28.85$

$$\text{Mols of air} = \frac{100}{28.85} = 3.465$$

Vol. at 60 deg. $= 379 \times 3.465 = 1313$ cu. ft.

Example 15—Weight of Natural Gas.

100,000 cu. ft. per day of the natural gas used in Example 11 is processed in a natural gasoline plant. What weight of gas is handled per day?

$$\text{Mols of gas: } \frac{100{,}000}{379} = 264$$

M. W. from Ex. 11 $= 19.44$

Wt. of gas per day $= 264 \times 19.44 = 5135$ lb. per day.

The density of this gas is:

$$\text{Density in lb. per cu. ft. at 60 deg.} = \frac{5135}{100{,}000} \text{ or } \frac{19.44}{379} = .05135$$

QUESTIONS

1. Define the coefficient of expansion?
2. What is the volume in cu. ft. of one pound mol of argon gas or of any gas at 60 deg. fahrenheit?
3. What is the specific gravity of crude oil of 0.85 gravity at 200 deg. fahrenheit? Answer—0.796.
4. What is the molecular weight of a naphtha that has a 50 per cent boiling-point of 460 deg. fahrenheit? Answer—178.
5. What is the molecular weight of a compound having the formula C_2H_4? Answer—28.

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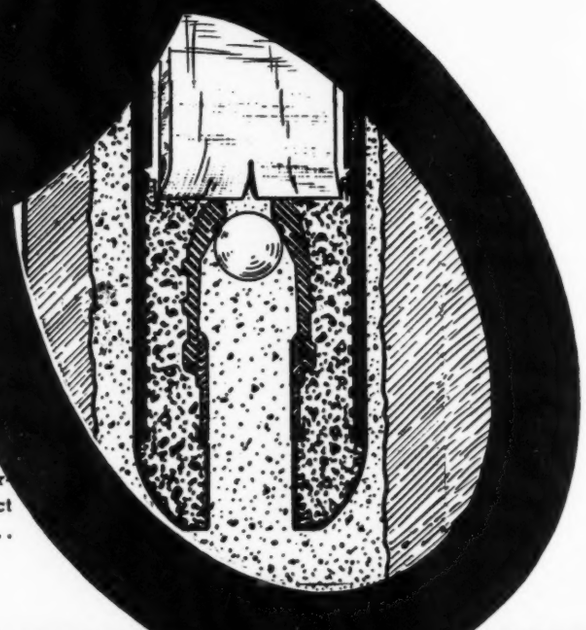

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LAUGH WITH BARNEY

Edited by BARNEY HORRIGAN

This story was told by the late Homer Guck, one time managing editor of the Houghton, Michigan, Mining Gazette. Homer related that he personally handled the society notes on a very swell wedding, one of the parties being the daughter of the most prominent family in town. The bridegroom was delayed by wash-outs on the railroad, and the wedding postponed. Homer wrote the notice as follows: "Owing to the non-arrival of the bridegroom, due to the condition of the road-bed, the wedding has been postponed." Then he went home without reading the proof. Next morning he discovered what a dropped line could do, when he read that "Owing to the non-arrival of the bed, the wedding was postponed."—*Contributed by George B. Steele.*

✦ ✦ ✦

"Pop, I need an encyclopedia for school."

"Encyclopedia hell; you can walk to school like I did!"—*Auburn Cajoler.*

✦ ✦ ✦

Boss: My wife heard that I took you out to dinner the other night.

Secretary: Well, what does that make me?

Boss: That makes you my former secretary.—*Reserve Red Cat.*

✦ ✦ ✦

Chaplain: My man, I will allow you five minutes of grace before the electrocution.

Condemned Man: Fine, bring her in. —*Reserve Red Cat.*

✦ ✦ ✦

Taken to the police station for disorderly conduct, the drunk, when asked his name by the sergeant, replied, "Smith."

"Give me your real name," ordered the sergeant.

"Well," said the drunk, "put me down as William Shakespeare."

"That's better," said Sarge. "You can't fool me with that Smith stuff."

✦ ✦ ✦

"Waiter," said the fussy diner, "I want some oysters. But they musn't be too large or too small, too old or too tough, and they musn't be salty. I want them cold and I want them at once."

"Yes, sir," bowed the waiter, "with or without pearls?"—*Annapolis Log.*

Atta Boy, Bill!

(From the Clayton, Texas, Herald)

Six members of the Mayfair Hiker's Club took the train Saturday to Dower's Grove for a long hike through the woods. The girls wore the conventional knickers. Billie Walker was on hand to see them off.

✦ ✦ ✦

The first jigsaw puzzle originated when a Scotch butcher dropped a dollar bill in the meat grinder.

✦ ✦ ✦

"I paid a hundred dollars for that dog—part bull."

"Which part is bull?"

"That part about the hundred dollars."—*Alabama Rammer-Jammer.*

✦ ✦ ✦

Her: How did you like the bridge party last night?

Him: It was fine until the cops looked under the bridge.—*Reserve Redcat.*

✦ ✦ ✦

"Do you know Sally Rand intimately?"

"Sure, I'm one of her fans."—*Pitt Panther.*

✦ ✦ ✦

"F-e-e-t. What does that spell, Johnny?" asked the teacher.

Johnny didn't know.

"What is it that a cow has four of and I have only two?" persisted the lady.

Johnny's answer was quite as surprising as it was unexpected.—*Virginia Skipper.*

✦ ✦ ✦

Have you heard about the Scotchman who bought only one spur? He figured if one side of the horse went the other was sure to follow.

✦ ✦ ✦

The absent-minded professor called his biology class to order shortly after the lunch hour. "Our special work this afternoon," he said, "will be cutting up and inspecting the inward workings of a frog. I have a frog in my pocket here to be used as a specimen."

He reached into his pocket and pulled out a paper sack, shook its contents on the table, and out rolled a nice-looking sandwich. The professor looked at it, perplexed, scratched his head and muttered: "That's funny. I distinctly remember eating my lunch."

The Real Offense

Burglar at home to young son: "I did not spank you for taking the jam, my boy, but for leaving your fingerprints."—*Scope.*

✦ ✦ ✦

A Distinction

Hoskins: So your son is in college? How is he making it?

Duffer: He isn't making it. I'm making it and he's spending it.

✦ ✦ ✦

Wasted Talent

Actor: So you're going to use me in your next play? Apparently you've discovered at last what I am.

Director: Yeah, hurry up and get into the hind legs of that stage horse over there.—*Red Ulcer.*

✦ ✦ ✦

Not Introduced

Sam (to wife at show): Mandy, tell dat Niggah to take his arm away from 'round yo' waist.

Mandy: Tell him yo'self. He's a puffect stranger to me.—*Brown Jug.*

✦ ✦ ✦

I went over to see a girl the other night. We turned on the radio and started to dance when her father came in. Without saying a word he grabbed me and threw me down the stairs. The next day I called the girl and asked her what the big idea was. "Oh," said she, "father is deaf and he couldn't hear the radio."—*Carnegie Tech Puppet.*

✦ ✦ ✦

Railway Agent: Here's another farmer suing us on account of cows.

Official: One of our trains has killed them, I suppose?

Railroad Agent: No, he claims our trains go so slow that the passengers lean out the windows and milk his cows as they go by.—*Annapolis Log.*

✦ ✦ ✦

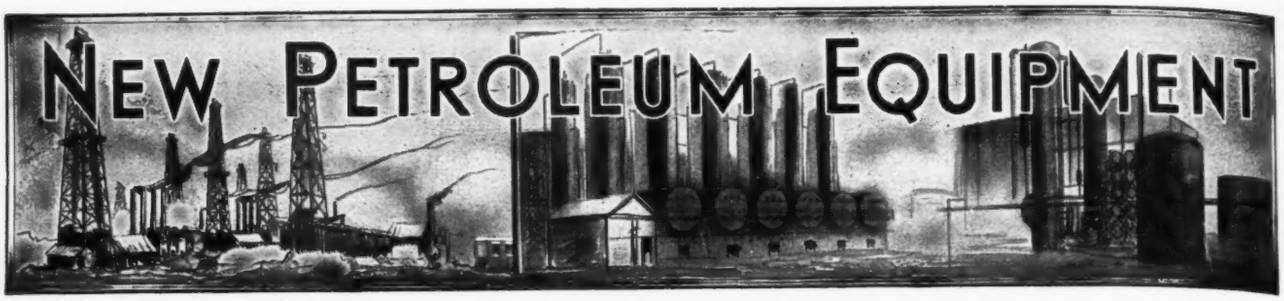
He had never played poker, but he didn't like to refuse. After the game one of his friends asked him:

"How did you come out?"

"Oh," he replied, "I managed to win a few dollars, although the other fellows cheated."

"What do you mean, cheated?" the friend inquired.

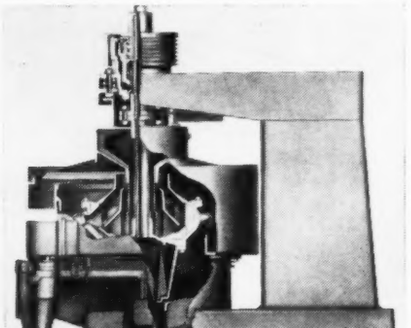
"Why," he explained, "we each got one card turned down and four turned up. I saw some of them turning up a corner of their down card to see what it was, but I didn't like to say anything, as I was winning anyhow."



Desander Developed by Merco Centrifugal Separator Co.

As an economic measure in the use of rotary drilling mud, a new desander has been developed by the Merco Centrifugal Separator Company, Ltd., San Francisco. It embodies the same basic principles that have been successfully used in a large separator known as Type A-30. The new model is for smaller capacities and will desand from 100 to 200 gal. of mud per minute, depending upon its viscosity, which is ample for a central mud plant handling from four to six wells.

The new separator is a self-contained unit mounted upon a single base and operated by an electric motor. It is de-



signed to extract substantially all sand from the mud. It embodies only one moving part: the rotor, which is suspended from an oscillating radial-thrust bearing at the top.

The principle of operation is simple. The feed, after passing through a coarse screen to remove large debris, enters the rotor at the top and immediately comes under the influence of the centrifugal force. The settling force is equal to 67 times that of gravity. The heavy components of the feed are projected to the periphery of the rotor while the "clean" carrying fluid passes out of the rotor over a weir near the center.

The solids, concentrated in some fluid, pass out of the rotor at the periphery through a series of nozzles. A large part of this discharge drops to the bottom of the housing, where it is picked up by the rotor and returned to the periphery. This return furnishes means for further concentrating the solids and flushing the entrance to the nozzles. The remainder of the discharge from the nozzles passes through a specific gravity device that regulates the density or concentration of the discharge.

This separator may be employed to prevent the loss of mud-weighting material. The machine will first separate light mud from the sand and mud-weight material. The latter is then run into the machine and the mud-weight is separated from the sand.

A bulletin describing the process can be procured from the Merco Centrifugal Separator Company, Ltd., 343 Sansome Street, San Francisco, California.

The Shull Swab

THE NEW SHULL SWAB, manufactured by the Shull Perforating Company, Inc., Long Beach, California, has expansion rubbers that may be adjusted to give any degree of expansion and wiping pressure desired.

When running into the hole the two rubber assemblies are "up." They "ride" tandem-like, with the top assembly against the shoulder of the mandrel shank. The bottom nut, being off its seat when running in, permits free passage of the fluid along the channels of the mandrel stem, through the dual rubber assemblies. When bottom is reached, the slidable rubber assemblies drop. The bottom nut of the lower assembly closes the fluid channels at the seat. Static load of the fluid column applies pressure to the swab rubbers from within. This fluid pressure is transmitted to the inner side of each rubber through a hole in the in ner sleeves.

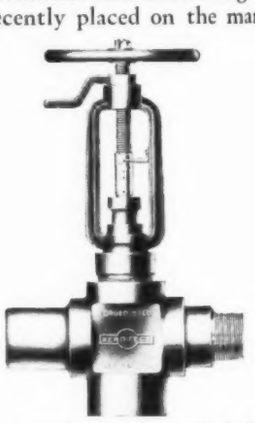
Kerotest Male End Crosses and Forged-Steel Control Chokes

FORGED-STEEL male and crosses for test pressures up to 6000 lb. per sq. in. and working pressures up to 3000 lb. per sq. in. are now being manufac-

tured by Kerotest Manufacturing Company, Pittsburgh. Available in four styles—four male outlets, three male, one female outlet, two male, two female outlets, and one male, three female outlets.

These Kerotest products are drop forgings, pressed and hammered to shape in special dies. All threads are full smooth threads, machined to A.P.I. line pipe gauges, insuring perfect joints and freedom from leaks.

The Kerotest Manufacturing Company recently placed on the market a

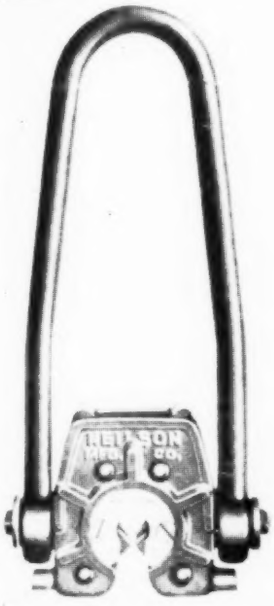


line of forged steel control chokes, designed for 6000 lb. test, 3000 lb. working pressure and in both male and female tee types. These chokes have forged-steel bodies, cast-steel yokes, heat-treated steel stems,, bronze-yoke bushings, hardened-alloy steel orifice bushings, and needle points.

Complete specifications of these products will be found in the new Kerotest Forged Steel Bulletin, copies of which will be sent upon request.

B-M-W Neilson Type "C" Sucker Rod Elevators

THE BRADFORD MOTOR WORKS, Bradford, Pennsylvania, has placed on the market the B-M-W Neilson Type "C" sucker rod elevators with interchangeable plates. The manufacturer states that special features of the elevators are that they are exceptionally strong, easy to operate, and thoroughly safe. The bodies are made of molybdenum steel and the bails of forged steel. Ease of operation is assured by the convenient location of operating latches and the replaceable feature of both the spring and plates. Being equipped with two latches, either of which will hold the rod, provides safety.



The heavy-duty elevator is designed to handle all rod sizes from 5/8-in. to 1-in., as well as 3/4-in. pipe. It is equipped with a 1-in. diameter bail, 16 in. in length. An 18-in. bail can be furnished without additional cost. The light-duty elevator handles 5/8-in. and 3/4-in. rods, being equipped with a 7/8-in. diameter bail, 12 1/2 in. in length. This elevator can be supplied with a 16-in. bail if desired. The heavy-duty elevator is recommended for wells of any depth, while the lighter one is recommended for wells up to 3000 ft. in depth.

Rear levers are standard equipment, but either the light- or heavy-duty elevator can be furnished with both front and rear levers. Interchangeable plates of hardened steel are an important feature, making it possible to handle any size or make rod in one elevator. The plates carry the rods, thus causing no wear on the elevator body.

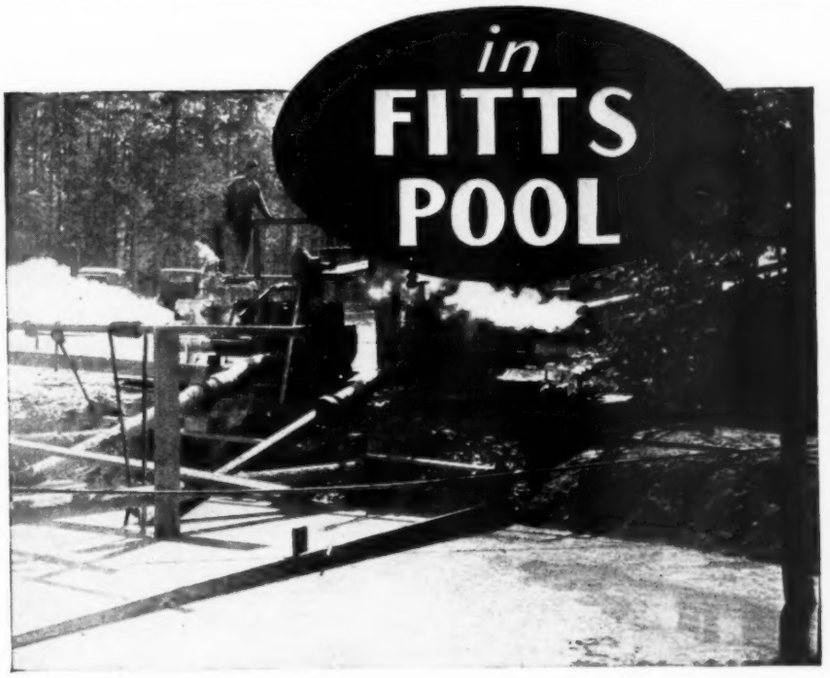
Axelson Develops Hardened Steel Liners

FOR some time the Axelson Manufacturing Company, Los Angeles, has been producing a super-service hardened-steel liner designed primarily for use in deep well pumps. The liner is constructed of a special molybdenum nickel alloy steel, heat-treated to afford extremely high surface hardness in the bore.

According to Axelson engineers, this liner presents a high resistance to abrasive action and friction. Axelson hardened-steel liners have been giving excellent results under extremely difficult conditions, it is stated.

The Axelson steel liner with hardened and honed interior surface offers a definite solution by which sand or fluid cutting and other extreme conditions can be overcome, company engineers state. Features of the liners are long life, low production costs, and less frequent repairs, whether the liners are used in tubing or rod type sectional liner pumps, it is pointed out.

A circular has been printed describing the new liner, copies of which may be obtained by writing the Axelson Manufacturing Co., Los Angeles.



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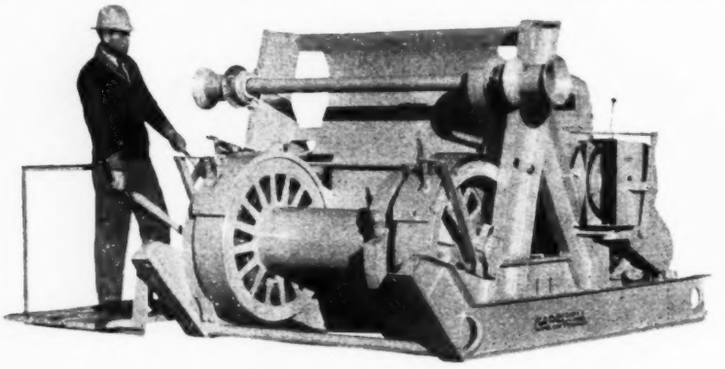
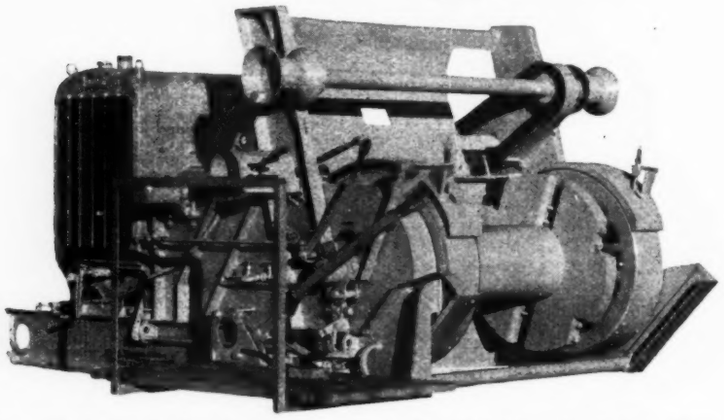
THE "Cardwell Allsteel" KSD-SR portable draw works, manufactured by Allsteel Products Manufacturing Company, Wichita, Kansas, is a combination rotary and standard tool drilling unit, light enough to be portable, yet strong enough to stand hard usage.

When equipped with spudding attachment, it is recommended for drilling with standard tools, to a depth of 3000 ft., and when equipped with the rotary table drive sprocket, for rotary drilling, to a depth of 2000 ft.; as an oil well servicing unit to a depth of 4500 feet.





The unit can be purchased without the spudder, but is completely drilled and equipped for the spudder, which may be obtained later and attached in the field. It is also available with sand line drum, directly above the lower drum.

The rotary table drive sprocket is driven direct from the countershaft, clutched and controlled from operator's position.

Water applied to the inner top part of the brake flanges keeps them cool at all times and adds to the ease and efficiency of operation. The controls are conveniently arranged at the side of the unit on the derrick floor, as in the conventional draw works.

The frame is of sturdy, electrically-welded construction, reinforced where extra strength is needed, eliminating surplus weight where excess strength is not needed. Throughout will be found alloy steels, heat-treated shafts, Timken, Hyatt and ball bearings, with patented wedge action brakes, and internally oiled drum bearings.

While designed as a portable draw works this unit also may be used for pulling rods and tubing, bailing, swabbing and general clean-out work, thus adding to its practical value as a versatile oil field unit. It has four speeds forward and one reverse, and is equipped with a Waukesha 6-cylinder engine, developing 100 hp. at 1800 revolutions per minute (factory rating). It can be supplied with Diesel or electric prime mover.

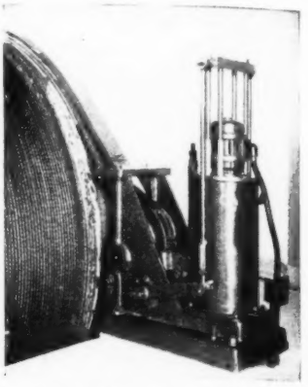
This draw works is also built in three larger models. It complies with public highway regulations.

General Electric Thrustor

A NUMBER of improvements in the G-E Thrustor, a self-contained combination of motor-driven centrifugal pump, oil chamber, and piston that produces a smooth straight-line thrust through a definite length of stroke especially suitable for the operation of clutches, brakes, valves, doors, etc., have been announced by the General Electric Company, Schenectady, New York.

The new line of Thrustors consists of a complete range of standard models providing ten combinations of thrust and stroke ratings varying from 50- to 3200-lb. thrust and from 2- to 16-in. stroke.

In the new Thrustor, the impeller housing of the centrifugal pump is stationary, a rigid shaft running in ball bearings connecting the impeller to the driving motor. A number of driving motor arrangements are available—



a.c. or d.c. All motors are totally enclosed (except d.c. and single-phase motors on the 50-lb. size) for protection against dirt and moisture. For single-phase service, capacitor motors are used on all Thrustors rated 100 lb. and greater thrust. For 25-cycle service, a special set-up gear train is provided to obtain the same impeller speed as that produced in 60-cycle service. For 50-cycle supply, impellers of slightly greater diameter are used to maintain rated thrust capacity.

Interchangeable base plates are available for clevis or rigid mounting of the device. Tilting as much as 45 degrees away from the vertical is permissible with the new Thrustors. It is also designed for continuous operation with the piston in the stalled position.

SKF Self-Aligning Roller Bearing

THIS 1500-lb. self-aligning roller bearing is the answer of SKF to industry's demand for large heavy-duty

bearings, say Messrs. R. H. DeMott, sales manager (left), and Robert C. Byler, advertising manager (right).

International Harvester Announces New Streamlined Models

THE new streamlined International trucks recently announced by the International Harvester Company include models ranging from one-half to five tons in capacity. The forerunner of this new line, the half-ton Model C-1 announced some time ago, has met with enthusiastic approval, the manufacturer states, and the larger models now being shipped from the factory carry the same distinctive lines and attractive finish.

New Streamlined International, Model C-55

The new models include the C-20, 1-1½-ton rated capacity, with a maximum allowable gross weight of 8300 pounds. It is powered by a 4-cylinder engine and is built in two wheelbases; namely, 133 and 157 inches. The 6-cylinder Model C-35, available in 136-, 160-, and 175-in. wheelbases, is powered by an International Harvester Model FAB-3 valve-in-head engine that develops 78 hp. at 3400 r.p.m. and 160.4 lb-ft. torque at 800 revolutions per minute. Compression ratio is 5.4 to 1 and displacement 222.7 cu. inches. The rated capacity of this model is 1½ to 2 tons, with a maximum allowable gross weight of 10,400 pounds.

The Model C-40, rated at 2 to 3 tons, with a maximum allowable gross weight of 13,000 lb., is equipped with the same power plant as the C-35, but instead of a four-speed conventional-type transmission the C-40 has a five-speed transmission with one reverse. Helical constant-mesh gears in third and fourth speeds assure quiet operation. This model is available in 145-, 155-, 170-, and 185-inch wheelbases.

The Model C-50 has a maximum allowable gross weight of 16,100 lb. with a rated capacity of three to four tons. It is built in 145-, 156-, 170-, and 185-in. wheelbases. This model is powered by the 6-cylinder valve-in-head International Model FBB engine, which, like the FAB engine employed in the Models C-35 and C-40, has replaceable cylinders, exhaust-valve seat inserts, replaceable precision-type bearings, and other features that contribute to its economy and efficiency. The Model C-50 engine has a 3⅝-in. bore and 4½-in. stroke with displacement of 278.7 cu. inches. It develops 82.3 hp. at 2800 r.p.m. governed speed and a peak torque of 191 lb.-ft. at 800 revolutions per minute. The rear axle is of the spiral bevel gear full-floating type.

The Model C-55, built to carry a total of 14,000 lb., including body, cab, and equipment, and rated at 3½ to 4½ tons, has a maximum allowable gross weight of 21,500 pounds. The Model C-60, 4 to 5 tons, has the same maximum allowable gross weight.

These models are alike with the exception of the rear axle. The Model C-55 has a spiral bevel drive-gear rear axle, while the Model C-60 has a double-reduction axle with herringbone gears for the first reduction. Both rear axles are of the full-floating type. These models are built in 140-, 156-, 170-, 190-, and 210-in. wheelbases. The power plant of the Models C-55 and C-60 is the 6-cylinder International Model FBB-3, also of the valve-in-head type, with replaceable cylinders, valve-seat inserts, and other important features. This power plant — bore, 3¾ in.; stroke, 4½ in.; displacement, 298.2 cu. in. — develops 90.4 b.hp. at 2800 r.p.m., its governed speed. Its peak torque is 213.5 lb.-ft. at 800 revolutions per minute.

All these new Internationals are of the same streamlined design, which is carried out in cabs and in panel bodies. Suitable body types to meet all hauling requirements are available for each of the new Internationals.

Another factor that contributes greatly to the attractive appearance of International models is the finish. The International Harvester Company has recently installed at its motor truck works equipment for applying and baking the latest type of enamel finish, which is baked on and which holds a permanent gloss after the trucks are in service. Chassis, cabs, and various body types are available in a wide selection of attractive colors.

**The material shown here consists of three complete cones weighing eight pounds; and 150 pounds of additional iron and steel cuttings.*

The Cavins is being used more extensively than ever before because it has proved conclusively that it is without an equal for the following purposes:

1. Breaking hard packed sand bridges. Also, ordinary sand may be cleaned out in about one-third the time formerly required for such jobs.
2. To recover such fish as pins, cones, discs, cuttings of all kinds, rubber, etc., by means of a junk trap or basket attached to bottom. (*See above).
3. Cleaning perforations, or screen. During ordinary bailing operations, the sand is drawn into the tool from behind the pipe, thoroughly cleaning and washing the perforations.
4. Cleaning out sand bridged tubing, for which the 2-inch size is used.
5. Cleaning out sand around and in "fish" in order to permit a socket or other fishing tool to grip the fish.

Write for bulletin and other data describing how The Cavins saves time, labor and money on all cleaning-out jobs. It's the easiest, cheapest, and best way.

THE CAVINS CO.

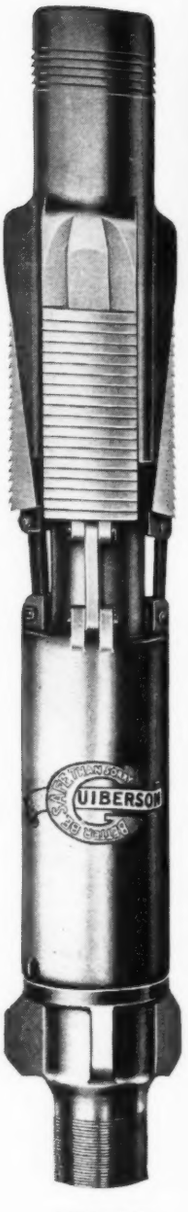
2853 Cherry Ave. Long Beach, Calif., U.S.A.
Cable Address: "Cavins, Long Beach"
R. J. EICHE, Foreign Representative
Branches at
Taft, Bakersfield, Goleta and Santa Paula, Calif.
Cavins Clean-Out Service:
Oklahoma City, Okla., and Wichita, Kansas
Cavins Bailer Service:
Houston and Kilgore, Texas, and Shreveport, La.

Larger SLIP AREA THAN EVER BEFORE

to meet deep well conditions

The tremendous weight of tubing and sucker rod strings in the deep wells of today caused us to design the GUIBERSON Type "E" Tubing Catcher. Note the length of the slips, as compared with earlier models.

The slip area of this model is ample to carry the loads imposed by modern deep wells, without danger of splitting or distorting the casing. The total slip area contacting casing varies from 43.65 sq. in. for 5¾" casing, to 112.5 sq. in. for casing from 8⅛" up. This exceeds the slip area of any other tubing catcher, except the Guiberson "Duplex" which averages the same slip area as the Type "E".



GUIBERSON Standard Type "E" Tubing Catcher

Yet with this increased slip area we have not cut down the by-pass area for fluid past the catcher head. The Type "E" offers *maximum slip area* combined with *maximum by-pass area*—a truly balanced design.

On very deep wells some operators take the extra precaution of using two catchers—or of using the GUIBERSON "Duplex" Tubing Catcher. The "Duplex" is designed with two sets of slips which operate in unison and engage the full 360 degrees of the casing's inner surface.

Our Type "E" Catcher can be equipped with our new Shoe-Type Anchor, as shown at left. This anchor represents a great improvement over the old friction-spring anchor, as it is only 8" long, and its cantilever springs do not come in contact with the casing walls. Hard-faced shoes ride the casing, exerting a uniform pressure at all times.

GUIBERSON pioneered the tubing catcher, and has consistently pioneered in improved design. More than 97,000 GUIBERSON Tubing Catchers have been sold.

Type "E" Tubing Catcher with Shoe Anchor

GUIBERSON Duplex Tubing Catcher

THE GUIBERSON CORPORATION

Box 1106, Dallas, Texas

LOS ANGELES: 1304 Security Title Insurance Bldg.
TULSA: 504 Wright Bldg.—HOUSTON: 635 Norfolk St.—PONCA CITY: 321 S. Osage St.
NEWARK, O.: First and Locust Sts.

GUIBERSON

BETTER BE SAFE UIBERSON THAN SORRY

JOE HOLMES, Caripito, Venezuela, chief engineer for the Standard Oil Company of Venezuela, is a visitor in the United States. He attended the recent A.P.I. meeting in Dallas.

W. K. KIRBY, consulting petroleum engineer of San Antonio, Texas, has returned from Italy, where he has been the past year doing consulting work on a proposed refinery and pipe line in Sicily.

FRANK H. CONRAD has taken a position as chemist with the Standard Oil Company of California at Richmond, California. He received his Ph.D. degree from the University of Washington in June.

DR. J. A. L. HENDERSON, consulting petroleum engineer, has returned to his offices in London, England, following a visit to Canada.

HENRY BOUREE, president of the Franco-Wyoming Oil Company, left New York November 24 on the liner Paris to return to Paris, France.

WILLIAM LANGE, chief engineer for the Wadhams Oil Company refinery at East Chicago, Indiana, sailed for Europe on December 1. While on the continent he will inspect several refineries of interest and also will visit his family in Germany. He expects to return in January.

P. W. PARKER, president of the Standard-Vacuum Oil Company, is en route to the Far East, where he will make an inspection of the company's properties.

H. C. B. BROWN, general manager of the Tucuyo Oilfields of Venezuela, recently made a visit to England.

W. E. MINTER, general manager and treasurer of the Conway Oil Company, has moved to Newcastle, Wyoming, from Charleston, West Virginia. The company is drilling a wildcat test on the Dewey Dome structure 20 miles south of Newcastle.

FRANK M. JACOBSON, Fort Worth, Texas, division chief clerk for the Continental Oil Company, has resigned to accept an executive position with the Buffalo Oil Company, Tulsa, Oklahoma, now in process of organization by H. P. Taubman and associates.

At a recent meeting of the American Society for Testing Materials, Charles McKnight, of the International Nickel Company, Inc., was elected chairman of the committee on ferro-alloys. He also is serving on several other committees of the society.

JOHN MCFADYEN, Casper, Wyoming, vice-president and Rocky Mountain division manager of the Ohio Oil Company, made a trip to California recently to inspect the company's operations.

R. R. IRWIN, president, and James P. Kem, vice-president and general counsel of the White Eagle Oil and Refining Company, with headquarters in Kansas City, Missouri, attended a federal labor board hearing at Casper, Wyoming, recently.

S. J. MCDOWELL, division superintendent for the Carnegie Natural Gas Company, Leechburg, Pennsylvania, and an employé of the company for 42 years, died at his home in Leechburg recently.

FRANK B. TAYLOR, formerly oil and gas supervisor for Wyoming, is now field representative in the Rocky Mountain area for the Sinclair Prairie Oil Company, making his headquarters at Casper, Wyoming.

K. R. KINGSBURY, president of the Standard Oil Company of California, and several of his assistants, were in London, England, recently on business.

CAMILLO GUITERREZ, production engineer of the Carter Oil Company in the Ponca City, Oklahoma, area, has resigned and returned to his home at Bogota, Colombia, where he becomes production engineer with the Imperial Oil Company. He is a graduate of the University of Oklahoma.

W. A. MONCRIEF, of Fort Worth, Texas, has been made president of the organization of oil operators in the new Sam Fordyce field in Hidalgo County, Texas. Other officials of the organization are B. H. King, Mission, vice-president; Paul J. Rogers, Houston, secretary-treasurer; members of the executive committee are Herman F. Heep, Houston; R. L. Wheelock, Corsicana; Guy Graham, Houston; Dick Harrison, Mission, and Joe Bridwell, Wichita Falls.

The many friends of W. G. Lane, partner in the Lane-Wells Company, Los Angeles, will be glad to learn that he is steadily recovering from serious injuries received in an automobile accident in West Texas early in November. According to information from E. R. Smith, manager of the Houston, Texas, branch of Lane-Wells, Mr. Lane was returned to Los Angeles after ten days' treatment in an El Paso hospital and is now able to be about. It is expected that he can soon resume his duties at the office.

PERCY C. JONES, president of The S. M. Jones Company of Toledo, Ohio, was a guest at the dinner of the Gridiron Club in Washington, D. C., December 8th.

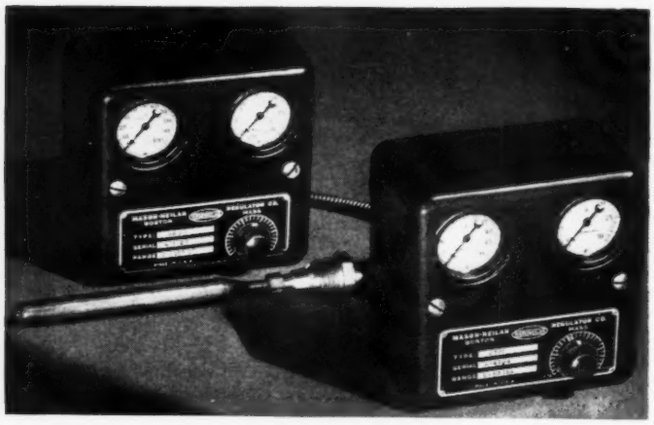
RICHARD P. ABELE, vice-president and director of the Sunray Oil Company, has resigned, effective January 1, and will become an independent oil operator.

J. M. MCINTIRE, of Casper, Wyoming, vice-president and general manager of the New York Oil Company, made a trip to Chicago recently on company business.

R. E. HARRIS, a sales representative of The Guiberson Corporation, Dallas, Texas, has returned to headquarters following a business and pleasure trip to Los Angeles.

MORGAN WALKER, chief petroleum engineer for the Lago Petroleum Corporation, Maracaibo, Venezuela, was in attendance at the Dallas meeting of the A.P.I.

• They're New
• They're Accurate
• They're Inexpensive



New Low Priced No. 2500 Indicating Pressure Controller and No. 3600 Indicating Temperature Controller.

These new Mason-Neilan Controllers are simple, rugged. Precise adjustments of sensitivity take only a minute.

• Here is our answer to the demands of American industry for an inexpensive means of accurately controlling process pressures and temperatures . . . two new Mason-Neilan controllers that now permit *every* plant to make the important savings formerly obtainable only with costly instrument control systems.

These two advanced controllers are surprisingly simple in design —hence easy to install, adjust, convert or repair. They control and at the same time indicate pressures and temperatures with unwavering accuracy. Their sensitivity may be adjusted instantly to meet plant conditions. Their construction is notably rugged. *Yet they are exceptionally low in price.*

There are many other distinctive features of these new Mason-Neilan Indicating Controllers which may enable you to smooth out your plant control and make substantial savings. A full description is given in an illustrated bulletin just off the press. *Write* for your copy of Bulletin No. 2500-C.

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REGULATOR COMPANY

1190 Adams Street, Boston, Mass.

BALTIMORE, Whitaker Building . . . . Morton Mc I. Dukehart & Co.
CHICAGO, 435 North Michigan Avenue . . Gordon Thomason, Manager
HOUSTON, 1400 Conti Street . . . . Maintenance Engineering Corp.
LOS ANGELES, 2446 Enterprise St. . . . . Tunnell & Co.
MONTREAL, Canada, 620 Catheart St. W. . . . Maurice Peiler, Manager
NEW YORK, 19 Rector Street . . . . . A. L. Krook, Manager
PHILADELPHIA, 930 North Front Street . . . Baeuerle & Morris, Inc.
PITTSBURGH, Clark Building . . . . . Bruce Irwin, Manager
ST. LOUIS, 2726 Locust Boulevard . . . . O'Brien Equipment Company
SYRACUSE, N. Y., 640 Gurney Building . O'Brien Steam Specialty Company
TULSA, 409 East Archer Street . . . . . Moorelane Company

YOU CAN BE SURE OF MASON-NEILAN PRODUCTS

Book Reviews

Fifty Reports on Mechanical Power Transmission from Motor Drive to Industry. By Robert W. Drake, E.E., M.E. Published by American Leather Belting Association, 41 Park Row, New York City (1934), 224 pages.

The transmission of mechanical power from electric motor to driven machine, by belting and by other means, is discussed in this volume. The problem is considered from the standpoint of design, maintenance, trouble elimination, comparative production and comparative costs, under a wide range of conditions and applications.

The book is entirely free from propaganda and deals with the practical plant application operation, and maintenance of all kinds of motor drives, including multiple V-belts, belting, chains and gears.

* * *

Gas Engineers' Handbook. Prepared by Gas Engineers' Handbook Committee of the Pacific Coast Gas Association, San Francisco, California. Reviewed and endorsed by the American Gas Association. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. (1934), 1008 pp., 344 illus. and graphs, 466 tables, 6x9 inches. Price $7.50.

This book gives the gas engineer a handbook comparable in purpose and execution to the standard manuals in other fields of engineering. Brought together in one volume are the physical, chemical, thermodynamic and other constants and formulas that the gas engineer uses most frequently in his work. Beginning with sections devoted to useful tables and information in fundamental mathematics, properties of material, liquids and gases, and heat and combustion, the book covers all phases of the industry, including gas manufacture, testing and measurement, transmission and distribution, and utilization, both industrial and domestic.

* * *

In reviewing "*The Engine Indicator*" by K. J. DeJuhasz in last month's issue of The Petroleum Engineer the price of the book was given as $2.00. This was in error, as the cost of the volume, which is published by the Instruments Publishing Company, 330 West 42nd Street, New York City, is $3.75.

R. D. Burris Kansas Representative for American Steel

R. D. (Bud) BURRIS

The American Steel and Wire Company of Chicago, manufacturers of wire lines, with offices in the oil country, announces the appointment of R. D. (Bud) Burris as field salesman in the State of Kansas. Burris is well known in the Kansas oil fields, having worked in that state many years for various supply companies.

•

"Cap" Eddleman Joins Ideco

E. H. Eddleman, widely known as "Cap," who for the past year has been connected with the P & C Committee in Washington, joined the organization of the International Derrick & Equipment Company recently. He will make his headquarters in Dallas, and will have supervision of sales in the Mid-Continent and Gulf Coast territory.

E. H. (CAP) EDDLEMAN

Eddleman attended the A.P.I. Convention at Dallas, accompanied by L. J. Brown and R. R. Bloss of the International Derrick & Equipment Company of Columbus, Ohio.

The International Derrick & Equipment Company, with plants located at Columbus, Ohio; Beaumont, Texas, and Torrance, California, is a subsidiary of the International-Stacey Corporation of Columbus, Ohio, of which L. J. Brown is president and R. R. Bloss, vice-president. Brown took over the management of the business in 1932, when the companies went through a re-organization program.

Bloss, who is in charge of the International Derrick & Equipment Company division of the business, has been connected with the oil well equipment business and the development of oil well machinery for over 15 years. He is one of the pioneer engineers who first introduced to the oil industry the "angle iron" steel derrick. He is directly responsible for the development of the "Crank Counterbalance," IDECO Geared Units and many other IDECO products.

Waukesha Motor Company Officials to Europe

Among those on board the U. S. S. Bremen when it sailed recently were H. L. Horning, president of the Waukesha Motor Company, Waukesha, Wisconsin, and J. B. Fisher, chief engineer. Messrs. Horning and Fisher are on a six-weeks' trip to Europe, where they will confer with such well known men in the internal combustion engine field and the oil industry as H. R. Ricardo, K. J. E. Hesselman, of the Hesselman Motor Corporation, Ltd., and G. D. Boerlage, of the Royal Dutch Shell Company. Ricardo is the holder of the patents on the Comet Diesel engine that is rapidly becoming popular for automotive service in this country, where it is manufactured by the Waukesha Motor Company.

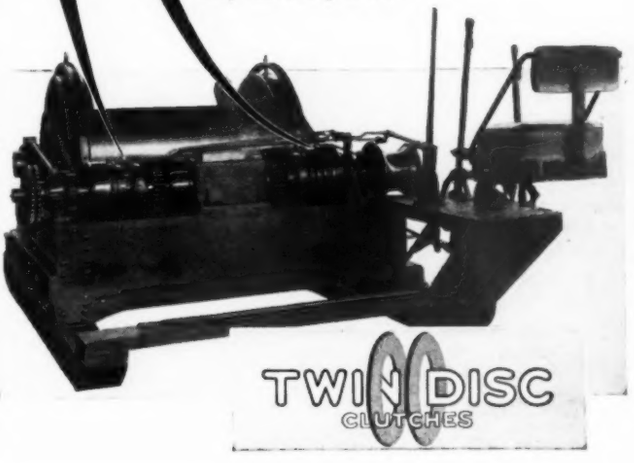
Sperry-Sun Moves Office to Houston

The Sperry-Sun Well Surveying Company on December 1 moved its Dallas office to Houston and established headquarters at the latter place in a new office building equipped with shop, laboratory, and garage facilities for the company's service trucks. The new location is at 3118 Blodgett Avenue. Executive offices of the concern continue to be at 1608 Walnut Street, Philadelphia, Pa.

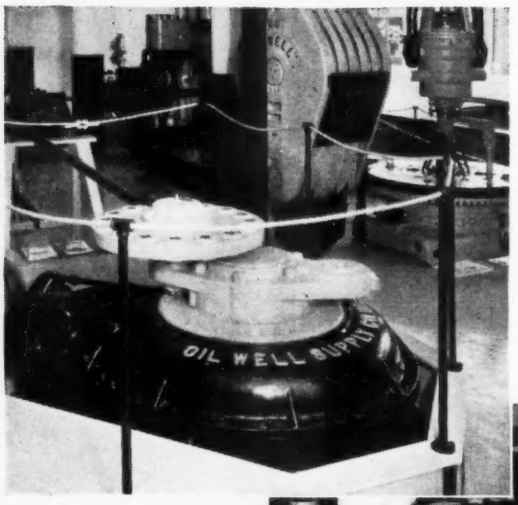
Twin Disc Multiple Disc Close Coupled Duplex Clutch

"the most desirable performance on hoist equipment"

The Muskogee Iron Works Model "A" Hoist is especially designed for all pulling and servicing operations on producing oil wells from 2800 to 5200 foot depths. The hoist's forward drive clutch is a 12-inch Twin Disc Multiple Disc Close Coupled Duplex Clutch . . . and the reverse clutch, which gives high speed reverse action on cable drum, is a 9-inch Twin Disc of the same type. A Twin Disc Power Take-Off Unit transmits the power from the hoist's engine. "We have found," says the Muskogee Iron Works, "by actual tests which were carried on by ourselves for approximately 18 months, that Twin Disc Close Coupled Type Clutches give the most desirable performance on hoist equipment." • *Write* for specific recommendations. Engineering data on request. *Twin Disc Clutch Company, 1329 Racine St., Racine, Wis.*

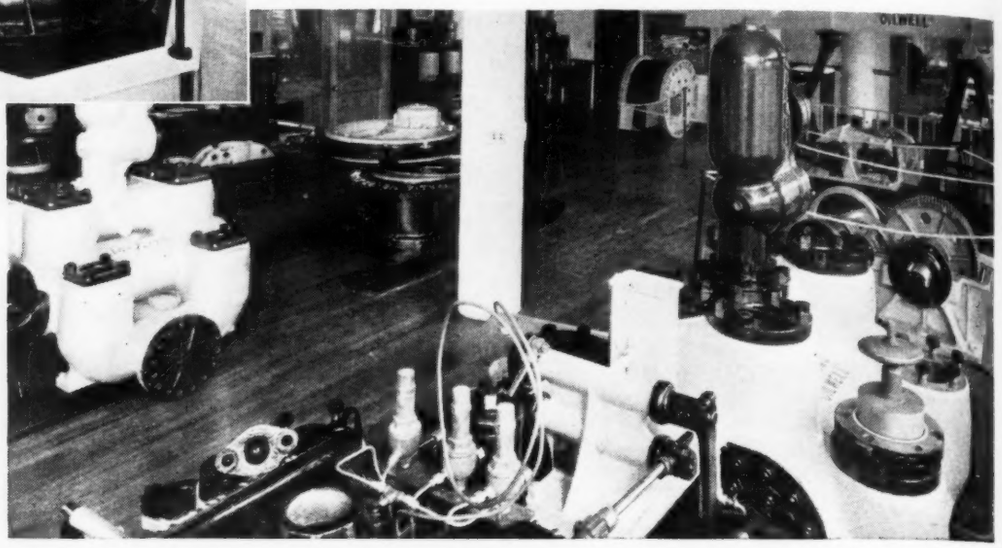


TWIN DISC CLUTCHES



Oil Well Displays Equipment During A.P.I. Meeting

DURING the meeting of the A.P.I. in Dallas the Oil Well Supply Company maintained an interesting exhibit of its machinery in the two large display rooms at the front of the Oil Well Building, 2001 Lamar Street. Approximately 1000 visitors viewed the displays. The photograph at the left shows a section of the large display room with an Imperial No. 80-SC Oilbath Geared Power in the foreground. Below is shown a portion of the smaller display room with an Imperial No. 20 steam slush pump in the foreground. All machinery was shown in operation.



100 Pounds or More Cut to Medium or Low Pressure

Fulton Toggled Reducing Regulator

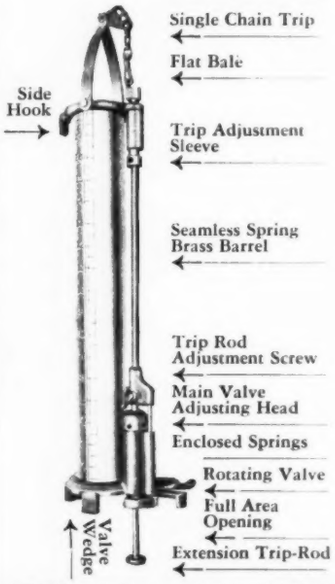
GAS pressures of 50 to 100 pounds or more in tanks or transmission lines are reduced to medium or low pressure in the distribution system by the Fulton Toggled Reducing Regulator. It can be equipped to operate with either natural or manufactured gas, maintaining the desired delivery pressure. For reversing furnaces, constructed with oversize valves. Also adapted to control of By-Product Coke Oven Gas. Ask for Circular, No. 2573.

The Chaplin-Fulton Mfg. Company
28-40 Penn Avenue Pittsburgh, Pa.

A THIEF YOU CAN TRUST!

and a thief that will SAVE you money

Check Each Feature



This is not an old-style oil thief with new gadgets, it's new from chain to trip-rod ... Complete in every detail. No special attachments to purchase. See page 498, Composite Catalog, for full information or write for illustrated folder.

For Sale by Leading Supply Companies

TULSA OIL THIEF COMPANY
W. L. WALKER CO., DISTRIBUTORS
800 S. MAIN STREET TULSA, OKLAHOMA

Shipment of Gaso Pumps to Venezuela

The accompanying photograph was taken in the plant of the Gaso Pump & Burner Mfg. Company, at Tulsa, Oklahoma, and shows four Gaso pumping units ready for shipment to a pipe line company in Venezuela. More than a dozen shipments

of similar units have been made by Gaso in the past two years to this same Venezuela company, indicating that these Tulsa-made pumps are "delivering the goods" in foreign service.

These pumps are Gaso Figure 1740 high-pressure pipe line pumps. They have interchangeable-liner fluid ends, and pump from 54 to 502 bbl. per hour, at 1400 to 300 lb. pressure. The pumps are driven by heavy-duty internal combustion engines through "V-belt" drive.

The Gaso Pump & Burner Manufacturing Company does a large export business. Gaso oil industry pumps are in wide use today in every foreign country producing oil.

Caterpillar Tractor Names Executives

C. Parker Holt was named executive vice-president of the Caterpillar Tractor Company, Peoria, Illinois, at a meeting of the board of directors held December 7. Thomas J. Conner was made vice-president in charge of manufacturing and was elected a director of the company to fill the vacancy caused by the recent death of Pliny E. Holt.

U. S. Rubber Promotes Harry M. Green

Appointment of Harry M. Green as manager of mechanical goods sales, Pacific Coast division, has been announced by H. A. Everlien, sales manager, mechanical goods division, United States Rubber Products, Inc., New York City.

In his new position Green will coordinate his activities with those of J. B. Brady, general manager of the Pacific Coast division, with headquarters in San Francisco. In addition, he will continue as manager of mechanical goods sales in the San Francisco branch.

Sullivan Company Installing New Machinery

F. Daly Sullivan, president of The Sullivan Company of Memphis, Tennessee, manufacturers of Konset, Kleen-A-Well, Fissurseal, Slush-Mix, Hef-T and other technical oil field life preservers, announces that modern machinery is being installed in their new factory at Memphis, Tennessee, and the company expects to be operating at full capacity by December 1. They were forced to cease operations temporarily because of the dismantling of their old factory at Memphis to make room for one of the large CWA projects, the South Third street viaduct.

HOW TO REDUCE PUMPING TROUBLES

●

INSTALL AXELSON PUMPS & SUCKER RODS

●

AXELSON MANUFACTURING CO.
P. O. Box 710, Vernon Station, Los Angeles
St. Louis 50 Church St., New York Tulsa
Mid-Continent and Eastern Distributor: Frick-Reid Supply Corp.
Rocky Mountain Distributor: Great Northern Tool & Supply Co.

Business Envelopes

Made to Order

We Manufacture and
Print Envelopes for
Every Type Enclosure.
Mail Orders Solicited.
Let Us Quote Prices.

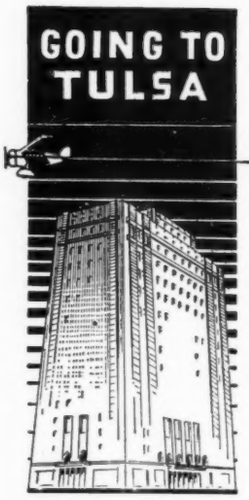
"It Pays to Use Good Envelopes"

OTEY

Envelope Company

DALLAS TEXAS

GOING TO TULSA



Then select the hotel that is the choice of more prominent people in all walks of life.

COMFORT PRESTIGE
EXCELLENT FOOD
All rooms with bath. Rates from $2.00.
E. J. STEWART, MANAGER

ALVIN HOTEL
TULSA, AAA OKLAHOMA

Petroleum Production Technology

from exploration to the finishing of wells

THIS IS A REVIEW and reference work of fundamentals, problems, methods and equipment—for all interested in a broad, practical understanding of petroleum production—covering those practices connected with the construction of wells, ready to produce oil.

New Second Edition

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OIL FIELD DEVELOPMENT

By LESTER C. UREN
Professor of Petroleum Engineering, University of California

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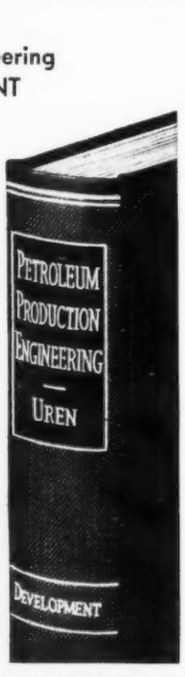

This is the first book of a two-volume edition, revised and enlarged to cover the far-reaching advances of recent years in this field. This book, complete in itself, gives a practical treatment of every phase of petroleum production engineering up to the point at which the wells are ready to produce. It introduces the fundamentals of field location and covers thoroughly the problems, methods and equipment of oil field development and modern deep-well drilling. • Every process and method of any consequence is fully explained and complete descriptions are given with illustrations of all commonly used oil field equipment, tools and appliances. In assembling this book an effort has been made to develop a well-balanced treatment that does not unduly stress some topics nor slight others.

Chapter Headings

1. *Properties, Occurrence and Associations of Petroleum.*
2. *Petroleum Exploration Methods.*
3. *Acquisition of Title to Oil Lands.*
4. *Developing the Field.*
5. *Drilling Equipment and Methods; General Features.*
6. *Churn Drilling Equipment and Methods.*
7. *Rotary Drilling Equipment and Methods.*
8. *Casing, Casing Appliances and Casing Methods.*
9. *Fishing Tools and Methods.*
10. *Oil-field Hydrology; Exclusion of Water from Wells.*
11. *Finishing the Well.*
12. *Well Records.*

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Cameron Iron Works, Inc., Houston, announces the transfer of L. D. (Lew) Hilton to Houston from Oklahoma City, where he has had charge of Oklahoma and Kansas sales the last two years. Hilton's oil field career dates back to early development in California, where he served the Rice Ranch Oil Company at Santa Maria as production superintendent. He was field superintendent at Ventura for the Bard Oil and Asphalt Company from 1909 to 1916, when he went with Pan American Petroleum Company as field superintendent. From 1920 to 1924 he was employed by a syndicate engaged in town lot drilling in the Los Angeles Basin fields, during which time he served a term as practical commissioner for the state on behalf of the operators and the oil division of the State Mining Bureau. In 1926 he came to the Mid-Continent territory for Regan Forge & Engineering Company, handling district sales. Prior to joining Cameron Iron Works in 1930, he managed the sales of several specialties of his own design for two years.

L. D. (Lew) HILTON

Lucey Products Corporation Moves Office Headquarters

Lucey Products Corporation, Tulsa, Oklahoma, announces the moving of their office headquarters to 910 South Boston Avenue, Tulsa, where they will occupy the eighth floor of the newly-named Tradesmen Building, formerly known as the Genet Building. The eighth floor has been entirely remodeled to suit their requirements. The company's former location at 224 East Brady Street was built for them in 1926 by the late Charles Page of Sand Springs.

Carl B. King Drilling Company Moves Office to Dallas

The Carl B. King Drilling Company on November 25 moved its headquarters from Houston, Texas, to Dallas. The company's offices are in Room 1509 Tower Petroleum Building.

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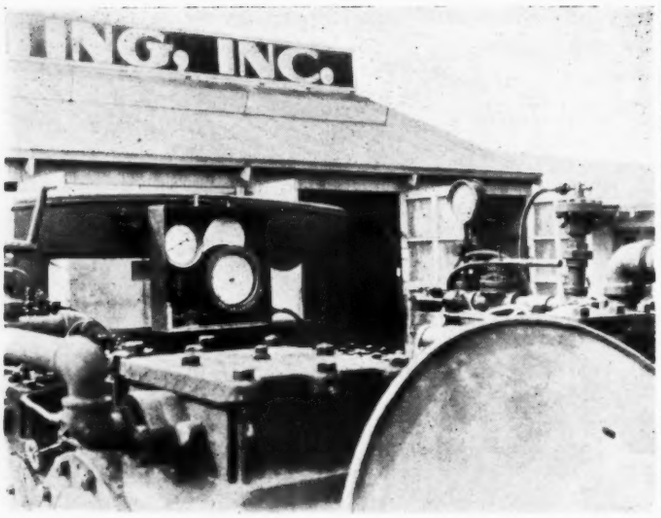

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